Rec'd PCT/PTO 31 MAY 2005
10/522833 #2.

SPECIFICATION

WOVEN OR KNIT FABRIC AND PROCESS FOR PRODUCING THE SAME

FIELD OF THE INVENTION

The present invention relates to a woven or knit fabric and a process for producing the same, more specifically, a woven or knit fabric comprising air-jet interlacing spun yarn, and a process for producing the same.

The present invention includes four aspects of first to fourth ones.

The first aspect of the present invention relates to a woven or knit fabric comprising an air-jet interlacing spun yarn which comprises a polyester staple fiber in which said fabric can exhibit ultraviolet shielding effect, anti-transparency and anti-pilling property by an unprecedented mechanism. Furthermore, this aspect relates to a woven or knit fabric which comprises a polyester staple fiber, can exhibit anti-pilling property, and gives excellent quick-drying property even if no special modified polyester is used.

The second aspect relates to a woven or knit fabric comprising an air-jet interlacing spun yarn which comprises a polyester staple fiber having both of hygroscopicity and an anti-pilling property, and further relates to a technique for improving drawbacks of conventional graft-polymerization-processed fibers, such as low physical properties, dimensional instability in humidity, wrinkles, low dryablility, and slimy (or smooth) texture.

The third aspect relates to a staple fiber woven or knit fabric excellent in bulkiness comprising an air-jet interlacing spun yarn which comprises a side by side crimped staple fiber, and also relates to a staple fiber

woven or knit fabric which is bulky and is excellent in heat retaining property, lightweightness, quick drying property, and anti-pilling property, and a process for producing the same.

The fourth aspect relates to a staple fiber woven or knit fabric excellent in bulkiness comprising an air-jet interlacing spun yarn which comprises a low-shrinkage staple fiber and a copolymer polyester staple fiber, and also relates to a polyester-based staple fiber woven or knit fabric which is bulky and is excellent in heat retaining property, lightweightness, quick drying property, anti-pilling property and others, and a process for producing the same.

BACKGROUND ART

Some examples of conventional methods for producing a polyester fiber woven or knit fabric exhibiting anti-transparency and ultraviolet shielding effect include a method of using a polyester fiber into which titanium oxide or the like is compounded, a method of incorporating a UV absorber into the surface of cloth, and a method of weaving or knitting fibers at a high density. In particular, the so-called full-dull fiber, which contains therein a large amount of titanium oxide, is high in anti-transparency and ultraviolet shielding effect, as disclosed in Japanese Patent No. 2888504, and the fiber is widely used for clothing or the like. In general, however, the full-dull fiber having a titanium oxide content of 3.0% by weight or more causes severe abrasion of guides, thread guides, reeds, etc., induces napping and thread breaking, and has poor process-passage property and a limit to color-developability. Thus, a remarkable restriction is given to

the representation of vivid colors, which can be achieved by conventional polyester fibers. In order to avoid these drawbacks, it is suggested to use a composite fiber comprising a core of a fiber containing a large amount of titanium oxide and a sheath of a usual fiber. However, the composite fiber is expensive and has an instable quality. The method of giving V absorbance by post-processing has drawbacks that the texture is hardened and costs increase.

As a polyester fiber the quick drying property of which is reputed to be good, there is suggested a long fiber which has a circular cross section or a modified cross section, such as an L-, W- or Y-shaped cross section, and which comprises conventional ultra fine filaments. In such a long fiber, the fiber surface area thereof increases and gaps between the filaments are made fewer so that the effect of capillarity is improved and the quick drying property is made good. Therefore, such a long fiber is often used for articles for sports, which have lightweight and gloss. Among polyester staple fibers, hollow yarns are generally used as lightweight and temperature-retention materials. However, the effect of diffuse reflection on the surface of the yarn is weak, and such an ultraviolet absorbing effect and visible ray transmittance as can be achieved by the articles of the present invention cannot be expected in the actual situation.

As an anti-pilling polyester fiber, the following is mainly used: an organic sulfonic acid group-containing copolymer polyester fiber or modified polyester fiber containing phosphorus or the like (for example, JP-A-7-173718 and JP-A-8-13274). With such a fiber, the fiber strength thereof is lowered by a resin or in spinning and drawing steps, and further the lowering of the fiber

strength (node strength) is promoted in the step of dyeing and finishing, so that naps on the surface of the cloth thereof are caused to fall away easily. The fiber is frequently used in a wool or rayon mixed-yarn woven fabric besides a knit fabric. However, in such a modified polyester fiber, in particular, an organic sulfonic acid group-containing copolymer polyester fiber, metal salts easily precipitate in the spinning thereof even when the fiber is in the form of a conventional fiber with a round cross section. Thus, the spinning performance thereof is not good. Spinning thereof into a yarn having a modified cross section is rather difficult. Furthermore, such a modified polyester fiber has a drawback that the fiber is poor in spinnability since the fiber has weak fiber strength. When an improvement in the spinnability is attempted, the strength of the fiber needs to be made high. In order to achieve the anti-pilling property thereof, some means for lowering the fiber strength is necessary in the step of dyeing. Furthermore, there are difficulties such that processing control is complicated in order to keep a constant quality in the step of dyeing.

When a treating solution to be used is in a strongly acidic pH range, for example, a pH of 3 to 4, in the dyeing process of such a modified polyester fiber, it is difficult to control a change in the pH of the solution in the processing and a variation between batches into minimum values. If the control is insufficient, the cloth easily becomes brittle or discolored. Thus, the practical strength of the cloth or the quality thereof deteriorates, so that the product value is remarkably damaged. Cloth having a fiber structure required to be dyed at a high temperature for a long time in order to obtain the anti-

pilling property is disadvantageous from the viewpoint of costs. In the case of cloth made of such a modified polyester fiber, the strength of yarn therein or the cloth largely decreases after the dyeing process. Accordingly, it is impossible to subject the cloth to a dyeing process again. This is very uneconomical.

In these years, an improvement in anti-pilling property depending on the method of spinning has been investigated, and a method using bundle spinning is proposed. In this method, interlacing between yarn filaments by high-speed air jet is a basic structure. Ends of the yarns are cramped inside the yarns. Accordingly, naps are few so that the anti-pilling property is improved. However, this method has a drawback that a harder texture is given than ring spun yarn because of the structure thereof. With polyester staple fiber woven or knit fabrics, it has been desired to develop a woven or knit fabric which has an anti-pilling property, an ultraviolet shielding property, anti-transparency, color-developability, a quick drying property and a cooling feeling together, and has a soft texture without using any full-dull fiber.

An object of the first aspect of the present invention is to obtain, at low costs, a woven or knit fabric which has less transparency and a high ultraviolet shielding effect without using any full-dull fiber (the titanium oxide content therein being generally 3.0% by weight or more) or any UV absorber even if the fabric is made into a thin white cloth, which has an excellent quick drying property and color-developability, which is rich in an anti-pilling property even if no special modified polyester fiber is used, and which has a soft texture.

Meanwhile, as a means for imparting hygroscopicity to

a polyester fiber, graft polymerization processing is well known. For example, graft polymerization described in JP-A-2000-45181 is known, but drawbacks to be solved are recognized in order to make the described graft polymerization practicable. That is, graft-polymerization-processed polyester fibers have drawbacks such as decrease in physical properties of dyed products thereof, in particular, decrease in the strength in humidity and wrinkles, a large dimensional change, and a slimy texture. Many proposals on two-component spun yarns in which a component having hygroscopicity is arranged in its core region have been made to overcome the drawbacks described above. However, those proposals also have problems, such as instability of the form of the fiber, due to swelling at the time of washing or of water-absorption, deterioration in dyeing quality, low hygroscopicity, and costs for spinning. Thus, in the actual situation, such fibers are hardly made practicable for clothing.

The main object of the second aspect of the present invention is to provide a woven or knit fabric for inner wear and outer wear of a polyester staple fiber type, or a woven or knit fabric of the same type suitable for towels, interlining cloth, interior goods such as mats and sheets, secondary materials, night clothes, and others. Another object thereof is to obtain a soft polyester staple fiber woven or knit fabric having both of hygroscopicity and an anti-pilling property, using a fiber graft-polymerization-processed with a polyester single-component spun fiber and further using an air-jet interlacing spinning technique without using any two-component spun fiber in which a component with hygroscopicity is arranged in a core region. A further object thereof is to provide a polyester staple

fiber woven or knit fabric which produces an improvement on drawbacks of graft-polymerization-processed fibers, such as the decrease in physical properties, dimensional instability in humidity, low drying property and slimy texture, and has both of hygroscopicity and anti-pilling property.

A stretching spun yarn made of a side by side latently-crimped fiber is widely known (see, for example, JP-A-6-287809). This material should be subjected to a cloth-crumpling treatment with a jet dyeing machine or the like in order to impart crimping. In this treatment, many nap pills are generated on the cloth surface. It is therefore essential to remove the nap pills by singeing, an alkali treatment or the like. For such a reason, it is impossible to perform the mixed-spinning or mixed-weaving or knitting thereof with a material having no alkali resistance, such as silk, wool, acrylic fiber, Promix, rayon, or spandex.

The third aspect of the present invention makes use of an air-jet interlacing spun yarn into which a side by side latently-crimped fiber is incorporated to provide a staple fiber woven or knit fabric which has an anti-pilling property and is stretching and bulky, and this aspect gives a stretching and bulky polyester staple fiber woven or knit fabric comprising an air-jet interlacing spun yarn and further, which fabric is soft and has both of bulkiness and an anti-pilling property only by a simple treatment, such as hot water treatment, without using special singeing or alkali treatment for obtaining an anti-pilling property nor generating production troubles substantially in the steps of spinning and dyeing processing.

The fourth aspect of the invention makes use of an

air-jet interlacing spun yarn in which staple fibers having different shrinkage effects are combined with each other to provide a staple fiber woven or knit fabric having an anti-pilling property and high bulkiness, and this aspect gives a highly bulky polyester staple fiber woven or knit fabric comprising an air-jet interlacing spun yarn, which fabric is soft, and has both of bulkiness and an anti-pilling property only by a simple treatment, such as hot water treatment, without using any conventional modified polyester fiber for obtaining an anti-pilling property nor generating production troubles substantially in the steps of spinning and dyeing processing.

DISCLOSURE OF THE INVENTION

The inventors have made eager researches in order to solve the above-mentioned problems and, as a result, completed the present inventions. Accordingly, the present invention includes the following structures:

The first aspect of the invention:

1. A polyester-fiber-containing woven or knit fabric comprising an air-jet interlacing spun yarn which comprises a polyester fiber having a titanium oxide content of less than 1.0% by weight, an anti-pilling property of the fabric of at least class 3 according to the A method in JIS L 1076, an ultraviolet shielding rate of at least 84%, and a visible ray transmittance of 40% or less; and

2. A process for producing a polyester-fiber-containing woven or knit fabric according to the above-mentioned item 1, using, as a constituent yarn of the woven or knit fabric, an air-jet interlacing spun yarn comprising a highly section-modified polyester fiber which has a titanium oxide content of less than 1.0% by weight, which has at least 3

projections continuously present on the fiber circumference in the fiber lengthwise direction, and which has a fiber cross section having a modified cross section degree (that is, a ratio of a circumscribed circle to an inscribed circle) of at least 1.8, or a hollow polyester fiber which has a titanium oxide content of less than 1.0% by weight and which has a hollow percentage of at least 8%, the number of naps having a length of at least 1 mm in the air-jet interlacing spun yarn being at least 30 and less than 350 per 10 meters, and the number of naps having a length of at least 3 mm therein being less than 15.

The second aspect of the present invention:

3. A polyester fiber woven or knit fabric, comprising an air-jet interlacing spun yarn which comprises a polyester staple fiber graft-polymerization-processed with a hydrophilic compound, and has a nominal water content of at least 1.5%, and an anti-pilling property of at least class 3;

4. The polyester fiber woven or knit fabric according to the above-mentioned item 3, wherein the dimensional change according to the F-1 method in JIS L 1018 is from −8 to 0% for a woven fabric and is from −3 to + 3% for a knit fabric;

5. A process for producing the polyester fiber woven or knit fabric according to the above-mentioned item 3 or 4, comprising using an air-jet interlacing spun yarn comprising a polyester staple fiber graft-polymerization-processed with a hydrophilic compound, the number of naps having a length of at least 1 mm and less than 3 mm in the air-jet interlacing spun yarn being from 30 to 350 per 10 meters, and the number of naps having a length of at least 3 mm therein being less than 15 per 10 meters;

6. A process for producing the polyester fiber woven or knit fabric according to any one of the above-mentioned items 3 to 5, wherein an air-jet interlacing polyester spun yarn or an air-jet mixed-yarn of an air-jet interlacing spun yarn and multi-filaments is used to produce the woven or knit fabric; and

7. A process for producing a polyester fiber woven or knit fabric according to any one of the above-mentioned items 3 to 6, wherein the polyester staple fiber has a fineness (denier) of at least 1.3 dtex, at least 3 projections present in the circumference of the fiber cross section thereof are continuously present in the fiber lengthwise direction thereof, and the modified cross section degree thereof is at least 1.8.

The third aspect of the present invention:

8. A stretching bulky staple fiber woven or knit fabric comprising an air-jet interlacing spun yarn which comprises at least 10% by weight of a side by side crimped staple fiber having a fineness of 1.0 to 6.0 dtex, wherein said fabric has an anti-pilling property of at least class 3;

9. The stretching bulky staple fiber woven or knit fabric according to the above-mentioned item 8, wherein the air-jet interlacing spun yarn comprises at least 10% by weight of a low-shrinkage staple fiber having a boiling water shrinkage rate according to JIS L 1015 of 4% or less;

10. The stretching bulky staple fiber woven or knit fabric according to the above-mentioned item 8 or 9, wherein at least one of the crimped staple fiber and the low-shrinkage staple fiber is a polyester staple fiber having a hollow cross section which has a hollow percentage of at least 5% or having a modified cross section which has at least one projection on the outer circumference of the fiber cross

section thereof and has a modified cross section degree of at least 1.8;

11. A process for producing a stretching bulky staple fiber woven or knit fabric, comprising using an air-jet interlacing spun yarn which comprises at least 10% by weight of a side by side latently-crimpled staple fiber having a fineness of 0.8 to 4.0 dtex and satisfying the following relationship (1) between the number (X) of naps of the spun yarn and the number (Y) of filaments in a cross section of the spun yarn:

$$0.4Y \leq X \leq 2.5Y \quad (1)$$

wherein X is the number of naps having a length of at least 1 mm per 10 meters and Y is the number of filaments in a cross section of the spun yarn, in which the number of the cross section filaments of the spun yarn is expressed by 5315 × 1.11/(English cotton yarn count thereof × dtex of monofilaments),

so as to prepare a woven or knit fabric, and

next shrinking the woven or knit fabric thermally;

12. The process for producing a stretching bulky staple fiber woven or knit fabric according to the above-mentioned item 11, wherein the boiling water shrinkage rate according to JIS L 1015 of the latently-crimped staple fiber is at least 20%;

13. The process for producing a stretching bulky staple fiber woven or knit fabric according to the above-mentioned item 11 or 12, wherein the air-jet interlacing spun yarn comprises 90 to 10% by weight of a low-shrinkage staple fiber having a boiling water shrinkage rate according to JIS L 1015 of 4% or less and 10 to 90% by weight of a latently-crimped staple fiber having a boiling water shrinkage rate according to JIS L 1015 of at least 20%; and

14. The process for producing a stretching bulky staple fiber woven or knit fabric according to any one of the above-mentioned items 11 to 13, wherein at least one of the latently-crimped staple fiber and the low-shrinkage staple fiber is a polyester staple fiber or polyester staple fibers having a hollow cross section which has a hollow percentage of at least 8% or having a modified cross section which has at least one projection on the outer circumference of the fiber cross section thereof and has a modified cross section degree of at least 1.8.

The fourth aspect of the present invention:

15. A bulky staple fiber woven or knit fabric comprising an air-jet interlacing spun yarn which comprises a low-shrinkage staple fiber having a boiling water shrinkage rate according to JIS L 1015 of 4% or less and a copolymer polyester staple fiber, the air-jet interlacing spun yarn comprising 10 to 60% by weight of the copolymer polyester staple fiber which is obtained by thermally shrinking the air-jet interlacing spun yarn, and said fabric has an anti-pilling property of at least class 3;

16. The bulky staple fiber woven or knit fabric according to the above-mentioned item 15, wherein the copolymer polyester staple fiber is a high-shrinkage staple fiber having a hollow cross section which has a hollow percentage of at least 8% or a modified cross section which has at least one projection on the outer circumference of the fiber cross section thereof and has a modified cross section degree of at least 1.8, and a boiling water shrinkage rate according to JIS 1015 of at least 20%;

17. The bulky staple fiber woven or knit fabric according to the above-mentioned item 15 or 16, wherein the low-shrinkage staple fiber is a polyester staple fiber having a

hollow fiber cross sectional shape or a modified fiber cross sectional shape having a modified cross section degree of at least 1.8;

18. The bulky staple fiber woven or knit fabric according to any one of the above-mentioned items 15 to 17, wherein the copolymer polyester staple fiber comprises isophthalic acid as a third component thereof;

19. A process for producing a bulky staple fiber woven or knit fabric, comprising using an air-jet interlacing spun yarn which comprises 90 to 40% by weight of a low-shrinkage staple fiber having a boiling water shrinkage rate according to JIS 1015 of 4% or less, and 10 to 60% by weight of a high-shrinkage staple fiber having a boiling water shrinkage rate according to JIS 1015 of at least 20% and satisfying the following relationship (1) between the number (K) of naps of the spun yarn and the number (A) of filaments in a cross section of the spun yarn:

$$0.4A \leq K \leq 3A \quad (1)$$

wherein K is the number of naps having a length of at least 1 mm per 10 meters, A is the number of filaments in a cross section of the spun yarn, in which the number of the cross section filaments of the spun yarn is 5315 × 1.11/(English cotton yarn count x dtex of monofilaments),

so as to prepare a woven or knit fabric, and

thermally shrinking the woven or knit fabric;

20. The process for producing a bulky staple fiber woven or knit fabric according to the above-mentioned item 19, wherein the high-shrinkage staple fiber is a copolymer polyester staple fiber having a hollow cross section which has a hollow percentage of at least 8% or a modified cross section which has at least one projection on the outer circumference of the fiber cross section thereof and has a

modified cross section degree of at least 1.8, and a fineness of 1.0 to 4.0 dtex; and

21. The process for producing a bulky staple fiber woven or knit fabric according to the above-mentioned item 19 or 20, wherein the high-shrinkage staple fiber is a copolymer polyester staple fiber having a maximum thermal stress of at least 0.08 cN/dtex at 60 to 160° C.

BEST EMBODIMENTS FOR CARRYING OUT THE INVENTION

Hereinafter, the present invention will be concretely explained.

The polyester-fiber-containing woven or knit fabric in the present invention is a woven fabric or knit fabric in which at least air-jet interlacing spun yarn is used as constituting yarn.

First, the first aspect of the present invention is described in detail.

The content of titanium oxide in the polyester fiber used in the first aspect is less than 1.0% by weight. In the case of a highly-modified cross section fiber in which at least 3 projections present on the fiber circumference thereof are present continuously in the fiber lengthwise direction thereof and the modified cross section degree is at least 1.8, the titanium oxide content is preferably 0.6% by weight or less, more preferably 0.5% by weight or less. If the titanium oxide content exceeds 1.0% by weight, the spinnability deteriorates and further a matting effect acts strongly so that whiteness may lower and color developability may be lost. In the present invention, a low titanium oxide content makes it possible to attain an ultraviolet shielding property and anti-transparency similar to those of full-dull fibers; therefore, the

present invention is characterized that titanium oxide does not need to be incorporated in a larger amount than needed.

In the case of hollow fibers, the reflectivity of light on the surface thereof tends to be lower than the above-mentioned highly section-modified fiber.. Thus, it is effective that the titanium oxide content therein is slightly larger. The titanium oxide content is preferably at least 0.4% by weight, more preferably about 0.8% by weight. When the number of hollows in the fiber is plural, the light reflectivity thereof is improved; therefore, in this case, the titanium oxide content can be made smaller and further the color developability can be improved than in the case that a single hollow is present.

Titanium oxide is mainly used. However, the following materials which have been hitherto used may be mixed with titanium oxide, if necessary: kaolinite, zirconium carbide, various pigments, tourmaline, a trace amount of radioactive fine powder which is obtained from rare ores or deep-sea water, an antibacterial deodorant, a bacteriostatic, etc.

The fiber which has a highly-modified cross section and is used in the first aspect needs to be in a form such that at least 3 projections are present on the fiber circumference thereof; the modified cross section degree thereof (a ratio of a circumscribed circle to an inscribed circle) is at least 1.8; and the projections are present continuously in the fiber lengthwise direction.

Any round cross section or flat cross section having a low fiber surface reflectivity, or any triangular cross sectional shape having a modified cross section degree of less than 1.8 is excluded, and the subject fiber should be a Y-shaped, cross-shaped or star-shaped fiber or the like that has a modified cross section degree of at least 1.8,

has a large elevation difference between the projections on the fiber surface and grooves therein, and has a large surface irregular reflectivity. The modified cross section degree is preferably at least 2.0 and less than 3.5, more preferably 3.0 or less. If the degree is 3.5 or more, the fiber strength tends to decrease. Such a highly section-modified fiber is generally bulky, and has an effect of giving cushion effect, which gives softness when the fiber is pressed. Accordingly, the fiber acts effectively for the soft-texture of the air-jet interlacing spun yarn of the present invention.

The hollow fiber used in the first aspect preferably has a hollow percentage of at least 8% and 45% or less. If the hollow percentage is 7% or less, the light reflectivity is poor. If it is 46% or more, the form-keeping is unfavorably difficult. The hollow percentage is preferably within the range of 15 to 30%. The hollow cross section of the fiber may be round, triangular, flat, rectangular, or the like. The number of hollows in a single monofilament may be one or more. The fiber may be hollow at the time of spinning, or may be a hollow fiber in which a specific component is dissolved in and removed from cotton, yarn, or a woven or knit fabric.

The content of the highly section-modified fiber and hollow fiber in the air-jet interlacing spun yarn is preferably at least 30%, more preferably at least 50%. These fibers may be used alone or in a mixture form. As long as the performance thereof is not impaired, other fiber, such as cotton, rayon, cupra, Polynosic or a cellulose fiber (examples thereof including a moisture-absorption exothermic fiber) such as purified cellulose such as Tencel, or a polyester, acrylic, acrylate or

modacrylic fiber, which has deodorizing property, bacteriostatic/antibacterial deodorant performance or other performances, or some other fiber.

The first aspect has a characteristic that an anti-pilling property can be imparted to a homopolymer polyester such as polyethylene terephthalate. It is possible to use this polyester fiber together with a polyester fiber of a cation dyeable polyester type, which is a copolymer of an organic component which contains a sulfonic acid metal salt group, or some other fiber by mixed-weaving, mixed-knitting, mixed-spinning and the like in order to obtain a vivid color, multicolor dyeing effect and so on. The content of the highly section-modified fiber or hollow fiber in the woven or knit fabric of the present invention is preferably at least 20%, more preferably at least 40%.

The fineness of the polyester fiber in the first aspect is preferably 3.5 dtex or less, more preferably 2.5 dtex or less from the viewpoint of an interlacement property, texture and yarn count. If the fineness is 3.6 dtex or more, the number of constituent filaments of the spun yarn decreases, and the rigidity thereof is strong, so that the interlacement property deteriorates and thus a hard texture and a low strength are obtained and a small yarn count is not easily obtained. Any staple fiber is expected to have a light transmission-blocking property based on the bulkiness resulting from crimping in comparison with long fibers. When the staple fiber is designed to have a cross sectional shape having a high modified cross section degree of at least 1.8 or a hollow cross sectional shape, the rigidity of the fiber becomes high. Thus, the fiber has a property rich in bulkiness in the form of spun yarn. As a result, the setting (permanent

set) of the fiber based on heat or physical force in subsequent steps gets less. Thus, the fiber is more bulky and better in a fiber form-keeping property and acts more effectively for preventing the transmission of ultraviolet rays or visible light than fibers having a round cross section or flat cross section, or fibers having a modified cross section degree of less than 1.8.

The polyester fiber in the first aspect can have a sufficient rigidity (tension or stiffness), which is equal to 2.0 dtex of a round cross section fiber, because of a large rigidity resulting from the cross sectional shape of the fiber, when the fineness of the polyester fiber is from 1.1 to 1.5 dtex. Therefore, the number of constituent filaments of the spun yarn can be increased in comparison with the conventional fibers having the same yarn count. As a result, the yarn strength and effects of the fiber for reflecting ultraviolet rays and blocking the transmission of visible light can be made high. The fiber in the first aspect also has advantageous effects of weakening the interminglement property of naps and improving the anti-pilling property because of the large rigidity of the fiber.

In the polyester staple fiber in the first aspect of the present invention, the number of crimps is appropriately from 8 to 20/25 mm. As the crimp number increases, the bulkiness and diffuse reflection on the cloth surface increases. The crimp number is preferably 10/25 mm or more. The cut length of the fiber can be from 32 mm to a burr cut, and may be appropriately selected in accordance with applications. In general, it is preferred that the length is not too long, and a preferable range thereof is from 32 to 51 mm from the viewpoint of the number of naps of the spun yarn, the interminglement degree

of the naps, the texture and the quality of the yarn.

When the above-mentioned polyester staple fiber is spun, the fiber is made into high-speed air-jet interlacing spun yarn not by ring-spinning but by open-end or bundle spinning. The yarns of these types are different from ring-spun yarn, and have an effect for restraining yarn naps on the basis of their structure. However, such a structure is unavoidably hardened. It is therefore desired to render spinning conditions in the invention conditions giving no damage to the texture, bulkiness and anti-pilling property of spun yarn and avoid a low spinning-out speed under a high air pressure, which increases the interlacement degree and hardens the texture.

The number of naps of the spun yarn spun-out in the first aspect is such that the number of naps having a length of at least 1 mm is at least 30 and less than 350, and the number of naps having a length of at least 3 mm is less than 15, each per 10 meters of yarn length. It is preferred that the requirements that these nap numbers are less than 300 and 10 or less, respectively, are simultaneously satisfied. When the spun yarn in which the fiber cross sectional shape and the fineness thereof are specified is prepared by high-speed air jet, as performed in the present invention, the spun yarn having a small number of naps can be obtained. When the respective nap numbers are 350 or more and 15 or more, a sufficient anti-pilling property cannot be obtained, in particular, for a bulky and loose structure such as a smooth or pile structure. Thus, the case is not preferred. If the number of naps having a length of at least 1 mm is less than 30, the spun yarn has a high interlacement degree and a small fineness. Thus, the anti-pilling property increases but

the bulkiness is poor and the cloth thereof has a hard texture. Therefore, such a yarn is not preferred. As a result, the ultraviolet shielding rate which is a target of the present invention lowers, and the transmittance of visible light increases unfavorably.

When at least the above-mentioned polyester spun yarn is used in the woven or knit fabric of the first aspect, it is possible to produce a polyester-fiber-containing woven or knit fabric having a transmittance of 40% or less to visible light having wavelengths of 380 to 780 nm, a shielding ratio of 84% or more against ultraviolet rays having wavelengths of 280 to 400 nm and an anti-pilling property of at least class 3, according to the A method in JIS L 1076. At this time, it is allowable to subject the polyester fiber to mixed-spinning, filament-mixing, mixed-twisting, mixed-weaving, or mixed-knitting with other fiber to form a structure in which the polyester fiber is used at a larger ratio in the cloth surface region, while the polyester fiber can be used alone.

To dye the woven or knit fabric of the first aspect, a conventional dyeing process is conducted after scouring in the same manner as other polyester fibers. For ordinary polyester fibers, high-pressure dyeing at 120 to 130°C is adopted. About cation-dyeable modified polyester, a dyeing from normal-pressure dying to high-pressure dyeing at 98 to 120°C is adopted. In the present invention, the woven or knit fabric may be finished without using any ultraviolet absorber together, while an ultraviolet absorber may be used together in a smaller amount than usual. As usual, the woven fabric may be subjected to a singeing or shearing treatment before or after the dyeing, or subjected to a light alkali treatment after singeing and then dyed,

thereby improving the cloth quality, anti-pilling property and texture thereof.

Next, the second aspect of the present invention is described in detail.

The second aspect of the present invention makes good use of the anti-pilling property of a polyester staple fiber woven or knit fabric and the hygroscopicity of a polyester fiber graft-polymerization-processed, which may be referred to as graft-polymerized hereinafter, so as to improve the decrease of strength thereof, which is a drawback of graft-polymerized fibers, in particular, the decrease of the strength, dimensional stability, wrinkles, slimy texture, etc. in humidity. The slimy texture and dimensional change in humidity can be improved without damaging hygroscopicity by subjecting the processed polyester fiber to mixed-spinning with an unprocessed polyester raw material or fiber.

The kind of the polyester staple fiber used in the second aspect is not particularly limited, and a homopolymer polyester such as polyethylene terephthalate is mainly used. Besides, the following may be used: a polyester copolymerized with a compound which contains an organic sulfonic acid salt group for obtaining heterochromatism or low-temperature dyeability; or a modified copolymer polyester such as a polyester copolymerized with a third component, such as isophthalic acid or neopentyl alcohol, for obtaining high-shrinkability. Titanium oxide may be incorporated thereinto in an amount of about 0.3 to 5.0% by weight. Furthermore, thereinto may be kneaded kaolinite, zirconium carbide, various pigments, fine carbon powder obtained from bamboo, BINCHO charcoal or the like, tourmaline, an antibacterial deodorant, a

bacteriostatic, an antifungal agent or the like.

In the second aspect, the strength decrease caused by graft polymerization processing is used to impart the anti-pilling property to the polyester fiber. The strength of the polyester fiber before the graft-polymerization-processing is preferably at least 3.0 cN/dtex, more preferably at least 4.0 cN/dtex. In the present invention, the strength of the spun yarn can be improved through the graft polymerization degree of the graft-polymerized fiber, or the mixed-spinning or filament-mixing ratio of this fiber to a fiber subjected to no graft polymerization. Accordingly, it is not always necessary to use a high-strength polyester fiber. It is therefore possible to use a polyester fiber having a sharply triangular, Y-shaped, cross-shaped, star-shaped, rectangular or flat cross section, or a flat cross section which may partially have projections, as well as a round cross section. A highly section-modified polyester in which any one of these fibers further has a hollow may be used. In the present invention, it is particularly effective to use a polyester fiber having a fineness of at least 1.3 dtex, which has, in the fiber lengthwise direction thereof, at least 3 projections continuously present on the circumference of the fiber cross section thereof, and which has a modified cross section degree (a ratio of a minor axis to a major axis) of at least 1.8. With such a fiber, bulkiness is more easily obtained and a soft cloth texture can be more easily obtained by cushion effect than with round cross section filaments. The modified cross section degree is preferably at least 2.0 dtex and less than 3.2. When it is less than 1.8 or 3.2 or more, the rigidity becomes small even if the fineness is large. This case is unsuitable for the present

invention.

The fiber having a cross sectional shape of the above-mentioned modified cross section degree has a larger surface area and is better in quick drying property than round cross section fibers. The woven or knit fabric made of the former fiber has a smaller water retentivity and thus better quick drying property than the woven or knit fabric made of a spun fiber with small fineness. In the case of knit fabrics, spun yarn having a small fineness gives a soft texture and further a product obtained therefrom easily loses its silhouette, while the knit fabric according to the present invention has features that it has tension or stiffness and the silhouette of a product obtained therefrom can be beautifully kept.

The fineness of the polyester fiber can be selected from a small fineness of about 0.5 dtex to a large fineness of 5.0 dtex in the accordance with applications, and should be decided by taking into account the increase in the fiber diameter in accordance with a graft degree. If the fineness is less than 0.5 dtex, the passage of the solution is bad in the course of graft polymerization so that a uniform graft degree is not easily obtained. Moreover, the strength of the fiber decreases when a graft-polymerized fiber is spun, so that cotton fly easily increases. If the fineness exceeds 5.0 dtex, only a spun yarn having a large yarn count is obtained and further the texture unfavorably becomes hard. The fineness after graft polymerization is preferably within the range of 1.0 to 3.0 dtex from the viewpoint of the texture and the process passability.

In the second aspect, the hydrophilic compound which is graft-polymerized to the polyester fiber is a hydrophilic group-containing vinyl monomer, a vinyl monomer

which can easily be made hydrophilic by a simple treatment such as hydrolysis or neutralization and so on, which has, in the molecule structure thereof, a polymerizable vinyl group and having an acid group, such as carboxylic acid or sulfonic acid, and/or a hydrophilic group, such as a salt thereof, a hydroxyl group, an ester group or an amide group.

Specifically, the following can be used: acrylic acid, an acrylic acid salt monomer such as sodium acrylate, aluminum acrylate, calcium acrylate, potassium acrylate, zinc acrylate or magnesium acrylate, acrylamide, 2-acrylamide-2-methylpropanesulfonic acid, methacrylic acid, allyl alcohol, sodium allylsulfonate, sodium vinylsulfonate, sodium methallylsulfonate, sodium styrenesulfonate, a methacrylic acid ester of polyoxymethylene, or the like. These may be used alone or in combination of two or more of them.

The graft polymerization processing can be applied to cotton or yarn of the polyester fiber by a known method using the above-mentioned monomer.

Specifically, there can be adopted a method of applying an aqueous processing solution containing the hydrophilic monomer, a catalyst such as a peroxide, and a swelling agent to the fiber or immersing the fiber into the aqueous processing solution, and then subjecting the resultant to heat treatment. The acid group is a group which increases the hygroscopicity or water absorbance by a treating the polyester fiber with a salt of an alkali metal, typically sodium, after neutralization and washing.

In the graft polymerization processing in the second aspect, the monomer concentration in the processing solution is preferably from 10 to 40% by weight, and the graft polymerization degree is preferably in a range from

2% by weight to about 30% by weight. If the ratio is less than 2% by weight, hygroscopicity is not easily obtained. When this degree is 30% by weight or more, a high hygroscopicity can be obtained but the fiber strength or the water retentivity becomes high so that wrinkles or dimensional change increases in humidity. Furthermore, the time for drying the fiber becomes long, so that the washable and wearable (W & W) property that polyester originally has is unfavorably lost.

In the second aspect, conditions for the processing are preferably decided so as to set the water content (at 20°C and 65% RH) after the alkali-metal-salt conversion in the range of about 1.5 to 15%.

The graft-polymerization-processed polyester fiber can be subjected to mixed-spinning or filament-mixing with a polyester fiber subjected to no graft polymerization. It is sufficient that the nominal water content thereof which is required for spun yarn is at least 1.5%. The graft polymerization degree and the mixing ratio of them can be adjusted by the percentage of the unprocessed fiber, and may be appropriately set in accordance with applications. For example, when only the graft-polymerized fiber is used, the water content therein is adjusted at 5% or less in order to control the dimensional change thereof within the range of the present invention. When not only the dimensional change but also slimy texture are desired to be improved, the improvement can be attained by preparing a spinning yarn comprising a highly-graft-polymerized fiber having a water content of at least 7% and less than 80% by weight of a polyester staple fiber or filaments subjected to no graft polymerization, in particular, a Y-shaped highly section-modified fiber or the like.

The upper limit of the nominal water content in the woven or knit fabric of the second aspect is preferably 7%, more preferably 6%. When the nominal water content exceeds 7%, the shrinkage of the cloth or product thereof is large when it is washed. Thus, the dimensional stability may deteriorate and the cloth may have a crinkled external appearance. Furthermore, as the water-retention amount increases, the drying time is extended accordingly. Thus, the washable and wearable property that polyester originally has tends to be damaged. The graft polymerization requires a sufficient graft polymerization time for achieving a nominal water content of at least 1.5%. It is unfavorable from the viewpoint of process step or equipments that the graft polymerization is applied to the cloth. The graft polymerization is preferably applied to the raw material or the spun yarn.

In the case of using the graft-polymerized material, it is possible to use 100% of graft-polymerized polyester or to subject the graft-polymerized material to mixed-spinning with a polyester material which has not been subjected to graft polymerization, or to prepare twisted thread composed of this spun yarn and spun yarn subjected to no graft polymerization. The mixed-spinning can be carried out in a card filament-mixing, sliver filament-mixing, a drawing step, a fine spinning step, etc.

The fiber to be mixed-spun may be any other staple fiber than polyesters. In the present invention, however, a polyester is mainly used from the viewpoint of physical properties, W & W property and dyeability. The form thereof may be a round cross section, hollow or highly section-modified fiber, or a cation-dyeable or normal-pressure dyeable fiber (cation dye or dispersed dye), a

yarn-dyed fiber, a solution-dyed fiber, or the like. These may be combined with each other in accordance with applications.

It is possible to subject the spun yarn to graft polymerization and to use the product as such. Furthermore, it is possible to subject the graft-polymerized yarn to air-jet interlacing with multi-filaments of a round cross section, hollow or highly section-modified fiber, a very fine fiber, a false-twisting processed fiber, a cation-dyeable or normal-pressure dyeable fiber, a yarn-dyed fiber, a solution-dyed fiber, or the like, to produce a structure in which the surface of the spun yarn is covered with the multi-filaments, and then use the resultant fiber. In such a case, the percentage of the blended graft-polymerized fiber is preferably 10% by weight or more and 75% by weight or less from the viewpoint of the hygroscopicity, strength, texture and dimensional stability of the spun yarn. When the graft polymerization degree is less than 10% by weight, it is necessary to perform high graft polymerization in order to obtain hygroscopicity. Accordingly, the fiber strength remarkably lowers. Thus, filaments thereof unfavorably fall away or undergo other inconveniences by repeated washing.

In the polyester staple fiber in the second aspect, the number of crimps is appropriately from 8 to 17 per 25 mm, and the cut fiber length can be from 32 mm to a burr cut, and may be appropriately selected in accordance with applications. In general, it is preferred that the length is not too long, and a preferable length is from 32 to 51 mm from the viewpoint of the number of naps of the spun yarn, the entangling degree of the naps, the texture and the quality of the yarn.

When the above-mentioned polyester staple fiber is spun, the fiber is made into a high-speed air-jet interlacing spun yarn not by ring-spinning but by open-end or bundle spinning. The air-jet interlacing spinning can be carried out by a known method, typically a method of JP-B-56-31370. The yarn of such a type is different from a ring-spun yarn, and has an effect for restraining yarn naps due to its structure, but have a structure the texture of which is unavoidably hardened. It is therefore desirable to render spinning conditions in the invention conditions giving no damage to the texture, bulkiness and anti-pilling property of a spun yarn and further avoid a low spinning-out speed under a high air pressure, which increases the interlacement degree and makes the texture hard. The distribution of the graft-polymerized yarn in the spun fiber may be randomly arranged, while a core-sheath structure yarn form, in which the graft-polymerized yarn is arranged in a larger amount in the core region, is preferable from the viewpoint of wearing feeling when the fiber absorbs humidity.

With the spun yarn spun-out in the second aspect, the number of naps having a length of at least 1 mm and less than 3 mm per 10 meters is from 30 to 350, and the number of naps having a length of at least 3 mm is 15 or less per 10 meters. More preferably, the requirements that these nap numbers are 300 or less and 10 or less, respectively, are simultaneously satisfied. When the respective nap numbers are more than 350 and 15 or less, a sufficient anti-pilling property cannot be obtained, in particular, with a bulk and loose structure such as a smooth or pile structure. Thus, the case is not preferred. If the number of naps having a length of at least 1 mm is less than 30,

the spun yarn has a high interlacement degree and a small fineness. Thus, the anti-pilling thereof increases but the bulkiness is poor and the cloth thereof unfavorably has a hard texture.

The spun yarn of the present invention having the small number of naps can be produced by specifying the fiber cross sectional shape and the fineness thereof and preparing a yarn by high-speed air jet.

Next, the fiber is made into a woven or knit fabric. At this time, this spun fiber may be used alone, or may be subjected to mixed-weaving or knitting with other fiber as long as the characteristics of the present invention are not impaired. The present invention attains the advantageous effects in a woven or knit structure having many irregularities, such as dappled cloth, jacquard cloth or pile, as well as a conventional woven or knit structure, such as smooth, sheeting, which is plainly knit, twill, or satin.

For these textures, it is not necessary to adopt any special dyeing processing step that is required when a copolymer polyester fiber is used to obtain an anti-pilling property, for example, high-pressure long-time conditions in a highly acidic bath having a pH of 3 to 4, alkali treatment conditions, or other processing conditions. Thus, it is advisable to set processing conditions as those in the prior art, or processing conditions suitable for the properties of the mixed-weaving or knitting material. In the case of ordinary polyester fibers, high-pressure dyeing at 120 to 130°C for 20 to 40 minutes is adopted. In the case of cation-dyeable type or normal-pressure dispersion dyeable type modified polyesters, normal-pressure dying or high-pressure dyeing at 98 to 120°C is adopted.

In the second aspect, it is possible to conduct post-processing treatment, such as treatment with a UV absorber, silk protein, amino acid or chitosan, or water-absorbing/antifouling, water repellent, antibacterial and deodorizing, or bacteriostatic processing. The present invention relates to a spun yarn having few naps, and is not required to be subjected to a singeing step in a cloth state as is performed with conventional ring-spun yarns. With the woven fabric thereof, it is possible to subject the woven fabric to singeing or shearing treatment after ordinarily-adopted dyeing, or singe the woven fabric, subject the singed fabric to a light alkali treatment to remove melt pills, and dye the woven fabric, thereby improving the cloth quality, anti-pilling property, and texture additionally.

The third aspect of the present invention is described in detail.

The third aspect of the present invention makes use of a side by side latently-crimped staple fiber having a large thermally-shrinking property as an air-jet interlacing spun yarn. In particular, the latently-crimped polyester staple fiber is subjected to mixed-spinning with other fiber so as to turn into the form of an air-jet interlacing spun yarn, and subsequently the spun yarn is made into a woven or knit fabric form and then subjected to heat treatment so as to attain sufficient shrinkage, thereby forming a fiber structure in which many gaps are formed between the yarn filaments to improve flexibility against the deformation of the interlacing spun yarn and impart bulkiness, soft feeling and flexibility to the yarn. Furthermore, a structure is made in which a large amount of latently-crimped yarns, which may cause yarn nap pills during dyeing

processing, are confined in the inner layer regions of the spun yarns, thereby restraining the formation of nap pills and in turn improving the cloth quality without conducting special singeing or alkali treatment.

In the description in relation to the third aspect, a fiber means a staple fiber unless otherwise specified.

The side by side latently-crimped staple fiber in the third aspect is preferably a polyester latently-crimped fiber obtained from a homopolyester, such as polyethylene terephthalate, polybutylene terephthalate or polytrimethylene terephthalate, or a copolymer polyester which comprises the above polyester as a basic backbone and is copolymerized with a third or fourth component or more. For example, such a side by side type fiber may be a side by side composite fiber in which a genral homopolyester as one component (A) is combined with a copolymer polyester as the other component (B) with the weight ratio of (A) to (B) of from about 45:55 to 55:45.

The copolymerizable component of the copolymer polyester in the third aspect is appropriately selected from acids and glycol components such as isophthalic acid, 5-sodium sulfoisophthalic acid, adipic acid, neopentyl glycol and diethylene glycol from the viewpoint of thermal shrinkage stress or a thermal shrinkage rate. The amount of the copolymerizable component is preferably from 4 to 18% by mole, more preferably form 5 to 12% by mole in the case of the copolymr of a high melting point type, or is preferably from 12 to 40% by mole, more preferably from 18 to 30% by mole in the case of the copolymer of a low melting point type. When the amount of the copolymerizable component is less than 4% by mole, the shrinkage of the fiber is insufficient. When the amount of the

copolymerizable component exceeds 40% by mole, stress relaxation easily appears in the post-processing, so that the shrinking force, raw material tenacity and thermal stability tend to deteriorate.

More specifically, the combination of polyethylene terephthalate (A) with a copolymer polyester (B) in which 5% by mole of isophthalic acid and 2% by mole of 5-sodiumsulfoisophthalic acid are copolymerized is used as a high melting point type having a melting point of about 240 to 260°C, while the copolymer polyester in which 30% by mole of, e.g., neopentyl glycol is copolymerized as the component (B) is used as a low melting point type having a melting point of about 140 to 160°C. It is preferred to use the component (B) of a high melting point type for a relatively heat-resistant combination in which a fiber to be mixed-spun is a cellulose fiber or the like, and to use a low melting point type for the use in a kit fabric using silk, wool or the like, for which heat resistance is not so highly required.

The hot water shrinkage rate of the latently-crimped fiber in the third aspect is obtained under in-liquid temperature conditions giving a maximum shrinkage rate without damaging properties of the fiber. The free shrinkage rate is preferably at least 20%, more preferably at least 30% at a boiling temperature in the case of the low melting point type or under high-pressure conditions in the case of the high melting point type. When the hot water shrinkage rate is less than 20%, the shrinkage expressing force is insufficient so that a difference in shrinkage rate between the interlaced fibers cannot be obtained and the soft feeling or flexibility may not easily be obtained.

The fineness of the latently-crimped fiber is from 0.8 dtex to 4.0 dtex, preferably from 1.0 dtex to 3.3 dtex, more preferably 2.5 dtex or less. If the fineness is less than 0.8 dtex, stress relaxation easily appears so that the shrinking force becomes insufficient to give no bulkiness. Additionally, the number of constituent filaments of the spun yarn increases so that naps are induced to easily form pills. If the fineness exceeds 4.0 dtex, the shrinking force increases but the fiber tends to have a structure in which thick filaments are arranged in a larger amount in the outer side than thin filaments by centrifugal force because of the mechanism of spinning. Thus, the latently-crimped fiber is abraded in a weaving or kitting step, a dyeing step, or wearing or washing of clothes, so as to increase the opportunity for inducing pills of naps and to remarkably interfere with the anti-pilling property. Therefore, the fineness of the latently-crimped fiber is preferably equal to or less than that of the fiber to be mixed-spun and the latently-crimped fiber is arranged in a larger amount in the inner side of the spun yarn.

The latently-crimped fiber is spun into an air-jet interlacing spun yarn, and made into a woven or knit fabric. The fiber in the woven or knit fabric state is subjected to heat treatment, so as to be thermally shrunk and crimped. Accordingly, crimped yarns having a fineness of about 1.0 to 6.0 dtex are present in the woven or knit fabric of the invention.

The cross sectional shape of the side by side latently-crimped fiber in the third aspect may be round, or the fiber may be a hollow fiber, or an elliptical, triangular, Y-shaped, flat, rectangular or some other cross-modified fiber as long as the ratio between the

above-mentioned (A) and (B) is in the above-specified range. The hollow or modified shape easily gives a large fineness, and generally tends to have a stronger thermal stress than a round cross section. Since the hollow or modified shape has rigidity, it easily generates resistance against a high-speed eddy current so as form a structure which is not easily scattered outwards. Thus, the shape acts more effectively. In order to obtain a difference in shrinkage rate between the mixed-spun yarns, it is necessary to heighten the shrinkage-exhibiting force of the latently-crimped fiber. Such a fiber shape makes it possible to further increase the advantageous effects of the third aspect.

When a high stretch of 30% or more is sought as a property of a woven or knit fabric, the side by side latently-crimped fiber in the third aspect is used alone or at in a percentage close to 100%. When a moderate stretch is desirable and importance is attached to the practical properties of a woven or knit fabric, the crimped fiber is subjected to mixed-spinning with a low-shrinkage fiber having a boiling water shrinkage rate of 4% or less. A material to be mixed-spun with the latently-crimped fiber, is preferably a fiber having a yarn cross sectional shape and fineness (specific gravity) giving a large rigidity. It is desirable to form a spun yarn structure in which the material is arranged in a larger amount in the outer side of the spun yarn so as to cover the latently-crimped fiber. A fiber matching therewith is a hollow fiber having a hollow percentage of at least 8% or a polyester staple fiber having at least one projection on the fiber circumference and having a modified cross section degree of at least 1.8.

In the case of the hollow fiber, the cross sectional shape of the hollow may be round, elliptical, triangular, flat, rectangular, or the like. A single hollow or plural hollows may be present in the cross section. The hollow(s) may be made at the time of spinning or after a specific component is dissolved and removed in the state of a raw material, a yarn or a cloth. The total hollow percentage is preferably 8% or more and less than 40%. If the total hollow percentage is less than 8%, the shrinking force lowers. If the total hollow percentage is 40% or more, the rigidity and the yarn-form retentivity are low so that the cross section is crushed. As a result, the shrinkage effect tends to decrease.

In the case of the cross-modified fiber, the fiber preferably has a modified cross section degree (a ratio of a circumscribed circle to an inscribed circle) of at least 1.8, preferably at least 2.0, and has a modified cross sectional shape having 3 or more projections on the circumference of the fiber cross section (such as a Y-shaped, cross-shaped, star-shaped or some other groove-shaped cross section). If the modified cross section degree is less than 1.8, a large stress relaxation is caused so that shrinking force is not easily generated in the mixed-spun yarn. Consequently, bulkiness and soft feeling, which are sought, are not easily attained.

The low-shrinkage fiber is not limited to a specific kind, as long as the fiber has a boiling after shrinkage rate of 4% or less in accordance with free shrinkage in boiling water for 20 minutes. A synthetic fiber is preferable, since the fineness, the fiber cross sectional shape and other properties can be arbitrarily selected. Particularly preferred is a homopolyester fiber made of

polyalkylene terephthalate, typical examples including polyethylene terephthalate and polybutylene terephthalate.

The mixing ratio of the side by side latently-crimped fiber in the spun yarn is preferably from 10% to 60% by weight, more preferably from 15% to 45% by weight. In particular, when the fiber is a highly section-modified fiber, the mixing ratio is preferably 40% by weight or less since shrinkage stress therein is strong. When the mixing ratio exceeds 60%, the shrinkage of the spun yarn increases so that the bulkiness of a spun yarn is not easily obtained, and thus the texture may deteriorate. When the mixing ratio is less than 10% by weight, sufficient difference of the shrinkage rate between the highly shrinkable latently-crimped fiber and the low-shrinkage fiber cannot be obtained so that the bulkiness of the spun yarn is insufficient, and thus a soft feeling may not be attained.

The low-shrinkage fiber which is mixed-spun with the latently-crimped fiber preferably has a fineness of about 0.1 to 5.0 dtex, and further the shape of the fiber cross section may be a conventional solid round cross sectional shape. Preferred is a hollow fiber having a hollow percentage of at least 8% or a polyester staple fiber having a modified cross section degree of at least 1.8 from the viewpoint of an anti-pilling property. Since the fiber having such a fineness and a form has a small number of filaments in the fiber cross section and has a relatively large rigidity, the yarn filaments are not easily interlaced so that the anti-pilling property is easily attained. However, the low-shrinkage fiber is not limited to the above fiber. The following fibers can be used as long as they satisfy an anti-pilling property of at least class 3: a natural fiber such as cotton, wool, silk or

hemp; a regenerated fiber such as rayon, Modal, Cupra, Polynosic, Lyocell, or di- or triacetate; a purified fiber; a semi-synthetic fiber; or a synthetic fiber such as polyamide fiber, polytrimethylene terephthalate fiber, a cation dyeable or normal-pressure dyeable polyester fiber, or a two-component spun yarn sliver type fiber of polyamide fiber and polyester fiber. These fibers may be used in combination.

Among the low-shrinkage fibers, the low-shrinkage synthetic fiber may contain 0.1 to 5.0% by weight of inorganic particles of titanium oxide, zirconium carbide, kaolinite, etc. When the fiber contains titanium oxide, zirconium carbide or the like, the fiber absorbs radiant heat from body heat and stores heat in between the yarn filaments so as to make the heat retaining property high. Furthermore, titanium oxide absorbs visible light and shields sunlight to prevent a temperature inside clothes from rising in summer. When the content of the inorganic particles exceeds 5.0% by weight, the spinnability deteriorates. When the content is less than 1.0% by weight, the heat retaining property or heat shielding effect is not easily attained.

When the low-shrinkage fiber is a highly-modified Y-shaped cross section fiber having a modified cross section degree of about 2.4, it deforms flexibly when an external force is applied to the fiber in the direction perpendicular to the fiber axis. When the external force is removed, the fiber recovers. Thus, the fiber has an appropriate cushion effect to contribute to the softening of the texture. The fiber has resistance against deformation in the lengthwise direction in the same way as a hollow cross sectional shape fiber. This weakens the

interlacement property between the yarn filaments so as to act effectively on an anti-pilling property synergistically with the effect of the fineness.

The boiling water shrinkage rate of the low-shrinkage fiber needs to be 4.0% or less in order to increase the difference of shrinkage rates between the fiber and the latently-crimped fiber and obtain a bulky and soft spun yarn. This rate is preferably 3.0% or less. The difference in fiber length between the high-shrinkage fiber and the low-shrinkage fiber in the mixed-spun yarn of the woven or knit fabric which is a finished product is preferably at least 7%, more preferably at least 8%. When this difference is less than 7%, the cloth tends to have poor bulkiness and softness. Additives contained in the spun yarn are not particularly limited, and may be an antibacterial deodorant, a bacteriostatic, an antifungal agent, a pigment and others besides the above-mentioned titanium oxide, zirconium carbide, kaolin and so on.

The boiling water shrinkage rate of the spun yarn in the third aspect is preferably 8%, more preferably at least 12%. The boiling water shrinkage rate is preferably at least 20% for a yarn of 100% of the latently-crimped fiber. If this rate is less than 20%, sufficient crimps may not be expressed. Accordingly, the stretch may not be easily obtained. According to the mixed-spun yarn in the present invention, an appropriate stretch can be kept and a soft texture using characteristics of the mixed-spun material can be obtained since the shrinkage of the spun yarn is appropriately restrained to give a full feeling by the incorporation of the highly shrinkable latently-crimped fiber and the low-shrinkage fiber having various properties.

In a process for producing the air-jet interlacing

spun yarn in the third aspect, that is, a process for obtaining a spun yarn from the highly shrinkable latently-crimped fiber, or from such a fiber and other low-shrinkage fiber, a coarse yarn produced by a uniform cotton mixing method, such as card cotton mixing, may be used. Preferably, the spun yarn is produced by preparing the coarse yarn having a core-sheath structure in which the latently-crimped fiber is arranged in a larger amount in the core region and the low-shrinkage fiber is arranged in a larger amount in the sheath region before a coarse yarn step based on sliver filament-mixing or the like, and then drafting the coarse yarn in a fine spinning step, or by drafting the coarse yarn of each of the latently-crimped fiber and the low-shrinkage fiber in a drafting zone in a fine spinning step, and then subjecting them to high-speed air-jet interlacing, such as open-end or bundle spinning. The yarn produced by the air-jet interlacing spinning method, which is different from ring spun yarn, has an effect of restraining yarn naps on the basis of its structure but tends to make the texture hard. With regard to spinning conditions in the present invention, it is necessary to take the texture, the bulkiness and the anti-pilling property of the spun yarn into consideration. It is desirable to avoid a low spinning-out speed under a high air pressure, which makes the interlacement degree large and makes the texture hard.

As the air-jet interlacing spun yarn has a longer fiber length and a smaller fineness, it tends to be more easily scattered by a high-speed eddy current and be arranged in a larger amount in the outer side of the spun yarn. It is therefore preferable to make the fiber length of the latently-crimped fiber equal to or larger than that

of the fiber to be mixed-spun and form a combination structure in which the latently-crimped fiber is arranged in a larger amount in the inner layer region of the spun yarn. The fiber length of the latently-crimped fiber is preferably from about 38 to 51 mm, while the length of the fiber to be mixed-spun is desirably not more than the above-mentioned length, for example, from about 44 to 32 mm.

The spun yarn spun-out in the third aspect is an air-jet interlacing spun yarn satisfying the following relationship (1) between the number (X) of naps of the spun yarn and the number (Y) of filaments in a cross section of the spun yarn:

$0.4Y \leq X \leq 2.5Y$ (1)

wherein X is the number of naps having a length of at least 1 mm per 10 meters, and Y is the number of filaments in a cross section of the spun yarn, in which the number of the cross section filaments of the spun yarn is expressed by 5315 × 1.11/(English cotton yarn count thereof × dtex of monofilaments).

However, when monofilaments having different finenesses are mixed and used, the respective numbers of naps are calculated on the basis of the mixing ratio therebetween, and the numbers are summed up.

Next, the resultant air-jet interlacing spun yarn is made into a woven or knit fabric. At this time, the spun yarn may be used alone, or may be mixed-woven or knit with other fiber within the scope of the present invention. The woven or knit fabric of the present invention attains the advantageous effect in a woven or knit structure having many irregularities, such as dappled cloth, jacquard cloth or pile, as well as a conventional woven or knit structure, such as smooth, sheeting, twill, or satin.

Furthermore, the resultant woven or knit fabric, in particular the high-shrinkage fiber in the spun yarn constituting the woven or knit fabric, is thermally shrunk by heat treatment, such as hot water treatment, which is similar to scouring, relaxing, dyeing or the like, thereby expressing the bulkiness of the spun yarn so as to yield a target staple fiber woven or knit fabric which exhibits a soft texture and an excellent anti-pilling property.

The spun yarn in the third aspect causes a shrinkage of about 5 to 40% in boiling water. It is therefore necessary to design the spun yarn and machines by taking into account the texture, weight per unit area, width, length and other properties of the finished woven or knit fabric. The boiling water shrinkage rate of the spun yarn in the present invention is preferably at least 8%, more preferably at least 12%.

In the dyeing process, it is necessary to sufficiently express the latent shrinking force which the spun yarn or the cloth has by scouring, a relaxing step, a dyeing step or the like, and it is desirable to use a jet dyeing machine. It is particularly desirable to subject the fabric to a uniform and sufficient relaxing treatment at a temperature of about 70 to 80°C for about 10 to 20 minutes in the scouring and relaxing steps, and subsequently raise the temperature. It is also preferable to use a softening agent.

The woven fabric of the third aspect may be subjected to singeing, mercerization or the like in order to improve the quality, texture and physical properties of the other fiber, in particular, cellulose fiber. However, one of the characteristics of the present invention resides in that the woven fabric can be finished without conducting special

singeing, an alkali treatment, an acid treatment, shearing or the like for obtaining the anti-pilling property of any synthetic fiber. The knit fabric is also finished without conducting an alkali treatment or an acid treatment for obtaining the anti-pilling property of any synthetic fiber. The knit fabric may be subjected to resin processing for obtaining the anti-pilling property of the other fiber, skin care, antibacterial and deodorant processing, or the like.

Hereinafter, the fourth aspect of the present invention is explained.

The fourth aspect of the present invention makes use of two staple fibers having largely different thermal shrinkage properties, and makes a high thermal stress type high-shrinkage polyester staple fiber having a specified fineness and a specific cross sectional shape into an air-jet interlacing spun yarn in the form of mixed-spun yarn with a low-shrinkage staple fiber having other specified fineness and other cross sectional shape, thereby restraining the number of naps into a specific number or less and simultaneously weakening the interlacement between the fibers to obtain an anti-pilling property, and further realizing a soft texture based on the shrinkage difference.

Again, in the description in relation to the fourth aspect, a fiber means a staple fiber unless otherwise specified.

The copolymer polyester in the fourth aspect is a polymer which has, as its basic backbone, a homopolyester, such as polyalkylene terephthalate, typical examples thereof including polyethylene terephthalate or polybutylene terephthalate, and is copolymerized with a bifuntional carboxylic acid such as isophthalic acid,

naphthalene dicarboxylic acid or adipic acid, and/or a polyol component such as neopentyl glycol or bisphenol A as a copolymerizable component.

In the copolymer polyester fiber in the fourth aspect, isophthalic acid is preferably used as a copolymerizable component from the viewpoint of the thermal shrinkage stress and thermal shrinkage rate of the fiber. The amount of the copolymerizable component is preferably from 4 to 12% by mole, more preferably form 5 to 10% by mole. When the copolymerization amount of isophthalic acid is less than 4% by mole, the shrinkage of the fiber is insufficient. When the above amount is 13% by mole or more, stress relaxation easily occurs in the post-processing, so that the shrinking force, raw material tenacity and thermal stability tend to decreae. A 5- sodiumsulfoisophthalic acid component or the like may be contained as the copolymerizable component as long as the basic performances of the copolymer polyester fiber in the present invention are not changed.

With the copolymer polyester fiber in the fourth aspect, the fiber cross sectional shape may be a general solid round shape. The fiber cross section is preferably a hollow having a hollow percentage of at least 8% or a Y-shaped, cross-shaped, star-shaped or some other modified-shape cross section that has projections on the circumference of the fiber cross section and has a modified cross section degree (a ratio of a circumscribed circle to an inscribed circle) of at least 1.8. The copolymer polyester fiber in the present invention is a high-shrinkage fiber. The boiling water shrinkage rate thereof and the boiling water thermal stress thereof are preferably at least 20% and at least 0.08 cN/dtex, respectively, and

are more preferably at least 30% and at least 0.15 cN/dtex, respectively, in accordance with free shrinkage in boiling water for 20 minutes. The use of such a high-shrinkage fiber as a raw material makes it possible to lower the mixing ratio of the high-shrinkage fiber in the mixed-spun yarn, restrain the shrinkage rate of the mixed-spun yarn and increase the shrinkage difference between the fibers, thereby increasing the bulkiness of the yarn.

In the case of the high-shrinkage hollow fiber, the cross sectional shape of the hollow may be round, elliptical, triangular, flat, rectangular, or the like. A single hollow or plural hollows may be present in the cross section. The hollow(s) may be made at the time of spinning or after a specific component is dissolved and removed in the state of a raw material, a yarn or a cloth. The total hollow percentage is preferably 8% or more and less than 40%. When total hollow percentage is less than 8%, the shrinking force lowers. When the total hollow percentage is 40% or more, the cross section is crushed so that the shrinkage effect tends to decrease.

The high-shrinkage polyester fiber preferably has a modified cross section degree (a ratio of a circumscribed circle to an inscribed circle) of at least 1.8, preferably at least 2.0, and has a modified cross sectional shape having 3 or more projections on the circumference of the fiber cross section (such as a Y-shaped, cross-shaped, star-shaped or some other groove-shaped cross section). When the modified cross section degree is less than 1.8, a large stress relaxation is caused so that shrinking force is not easily generated in the mixed-spun yarn. Consequently, bulkiness and soft feeling, which are sought, are not easily obtained.

The fineness of the high-shrinkage polyester fiber is preferably from 1.0 to 4.0 dtex, more preferably from 1.4 to 3.5 dtex. If the fiber is too thick, the cloth thereof becomes coarse and hard and thus lacks softness. If the fiber is too thin, the shrinking force decreases so that the spun yarn tends to have an insufficient bulkiness.

In the fourth aspect, the spun yarn, which may be referred to as a mixed-spun fiber hereinafter, comprises the above-mentioned high-shrinkage fiber and a low-shrinkage fiber having a boiling water shrinkage rate of 4% or less.

The low-shrinkage fiber is not limited to a specific kind as long as the fiber has a boiling water shrinkage rate of 4% or less. A synthetic fiber is preferred, since the fineness, the fiber cross sectional shape and other properties thereof can be arbitrarily selected. Particularly preferred is a homopolyester fiber made of a polyalkylene terephthalate, typical examples including polyethylene terephthalate and polybutylene terephthalate.

The mixing ratio of the high-shrinkage polyester fiber in the spun yarn is preferably from 10% to 60% by weight, more preferably from 15% to 45% by weight. In particular, when the fiber is a highly section-modified fiber, the mixing ratio is preferably 40% by weight or less since shrinkage stress therein is strong. When the mixing ratio exceeds 60%, the shrinkage of the spun yarn itself increases so that the bulkiness of a spun yarn is not easily attained, and thus the texture may deteriorate. When the mixing ratio is less than 10% by weight, sufficient difference of the shrinkage rates between the high-shrinkable polyester fiber and the low-shrinkage fiber cannot be obtained so that the bulkiness of the spun yarn

is insufficient, and thus a soft feeling may not be attained.

According to the fourth aspect, the mixing ratio of the high-shrinkage fiber in the spun yarn can be made small using a high-shrinkage polyester fiber as a high-shrinkage fiber, as described above, so as to moderately restrain the shrinkage of the spun yarn, increase a full feeling and further yield a soft texture by making use of the features of mixed-spun material.

The low-shrinkage fiber used in the fourth aspect preferably has a fineness of about 0.1 to 5.0 dtex. Although the shape of the fiber cross section may be a conventional solid round cross sectional shape, preferred is a hollow fiber having a hollow percentage of at least 8% or a polyester staple fiber having a modified cross section degree of at least 1.8 from the viewpoint of an anti-pilling property. Since the fiber having such a fineness and a form has a small number of filaments in the fiber cross section and has a relatively large rigidity, the yarn filaments are not easily interlaced so that the anti-pilling property is easily obtained. However, the low-shrinkage fiber is not limited to the above fiber. The following fibers can be used as long as they satisfy an anti-pilling property of at least class 3: a natural fiber such as wool, cotton, silk or hemp; a regenerated fiber such as rayon, Modal, Cupra, Polynosic, Lyocell, or di- or triacetate; a purified fiber; a semi-synthetic fiber; or a synthetic fiber such as polyamide fiber, polytrimethylene terephthalate fiber, a cation dyeable or normal-pressure dyeable polyester fiber, or a two-component spun yarn sliver type fiber of polyamide fiber and polyester fiber. These fibers may be used in combination.

Among the low-shrinkage fibers, the low-shrinkage synthetic fiber may contain 0.1 to 5.0% by weight of inorganic particles of titanium oxide, zirconium carbide, kaolinite or the like. When the fiber contains titanium oxide, zirconium carbide or the like, the fiber absorbs radiant heat from body heat and stores heat in between the yarn filaments so as to make the heat retaining property high. Furthermore, titanium oxide absorbs visible light and shields sunlight to prevent a temperature inside clothes from rising in summer. When the content of the inorganic particles exceeds 5.0% by weight, the spinnability deteriorates. When the content is less than 1.0% by weight, the heat retaining property or heat shielding effect is not easily attained.

When the low-shrinkage fiber is a highly-modified Y-shaped cross section fiber having a modified cross section degree of about 2.4, it deforms flexibly when an external force is applied to the fiber in the direction perpendicular to the fiber axis. When the external force is removed, the fiber recovers. Thus, the fiber has an appropriate cushion effect to contribute to the softening of the texture. The fiber has resistance against deformation in the lengthwise direction, in the same way as a hollow cross sectional shape fiber. This weakens the interlacement property between the yarn filaments so as to act effectively on an anti-pilling property synergistically with the effect of the fineness.

The boiling water shrinkage rate of the low-shrinkage fiber needs to be 4.0% or less in order to increase the difference of shrinkage rates between the fiber and the high-shrinkage fiber and obtain bulky and soft spun yarn. This rate is preferably 3.0% or less. The difference in

fiber length between the high-shrinkage fiber and the low-shrinkage fiber in the mixed-spun yarn of the woven or knit fabric which is a finished product is preferably at least 7%, more preferably at least 8%. When the difference is less than 7%, the cloth tends to have poor bulkiness and softness. Additives contained in the spun yarn are not particularly limited, and may be an antibacterial deodorant, a bacteriostatic, an antifungal agent, a pigment and others besides the above-mentioned titanium oxide, zirconium carbide, kaolin and so on.

The boiling water shrinkage rate of the spun yarn in the present invention is preferably at least 8%, more preferably at least 12%.

In a process for producing the spun yarn in the fourth aspect, that is, a process for mixed-spinning the high-shrinkage polyester staple fiber and the low-shrinkage fiber, a coarse yarn produced by a uniform cotton mixing method, such as card cotton mixing, may be used. Preferably, the spun yarn is obtained by preparing the coarse yarn having a core-sheath structure in which the high-shrinkage fiber is arranged in a larger amount in the core region and the low-shrinkage fiber is arranged in a larger amount in the sheath region before the coarse yarn step based on sliver filament-mixing or the like, and then drafting the coarse yarn in a fine spinning step, or by drafting the coarse yarn of each of the high-shrinkage fiber and the low-shrinkage fiber in a drafting zone in a fine spinning step, and then subjecting them to high-speed air-jet interlacing, such as open-end or bundle spinning. The yarn produced by the air-jet interlacing spinning method, which is different from ring spun yarn, has an effect of restraining yarn naps on the basis of its

structure but has a structure the texture of which is unavoidably hardened. With regard to spinning conditions in the present invention, it is necessary to take the texture, bulkiness and the anti-pilling property of spun yarn into consideration. It is desirable to avoid a low spinning-out speed under a high air pressure, which makes the interlacement degree large and makes the texture hard.

The spun yarn spun-out in the fourth aspect is an air-jet interlacing spun yarn satisfying the following relationship (1) between the number (K) of naps of the spun yarn and the number (A) of filaments in a cross section of the spun yarn:

$$0.4A \leq K \leq 3A \quad (1)$$

wherein K is the number of naps having a length of at least 1 mm per 10 meters, and A is the number of filaments in a cross section of the spun yarn, in which the number of the cross section filaments of the spun yarn is expressed by 5315 × 1.11/(the English cotton yarn count thereof × the dtex of the monofilaments).
However, when monofilaments having different finenesses are mixed and used, the respective numbers of naps are calculated on the basis of the mixing ratio therebetween, and the numbers are summed up.

Next, the resultant spun yarn is made into a woven or knit fabric. At this time, the spun yarn may be used alone, or may be mixed-woven or knit with other fiber within the scope of the present invention. The woven or knit fabric of the present invention achieves the advantageous effect in a woven or knit structure having many irregularities, such as dappled cloth, jacquard cloth or pile, as well as a conventional woven or knit structure, such as smooth, sheeting, twill, or satin.

Furthermore, the resultant woven or knit fabric, in particular the high-shrinkage fiber in the spun yarn constituting the woven or knit fabric, is thermally shrunk by heat treatment, such as hot water treatment, which is similar to fine spinning, relaxing, dyeing or the like, thereby expressing the bulkiness of the spun so as to yield a target staple fiber woven or knit fabric which exhibits a soft texture and an excellent anti-pilling property.

The spun yarn in the fourth aspect causes a shrinkage of about 5 to 40% in boiling water. It is therefore necessary to design the spun yarn and machines, by taking into account the texture, weight per unit area, width, length and other properties of the finished woven or knit fabric. The boiling water shrinkage rate of the spun yarn in the present invention is preferably at least 8%, more preferably at least 12%.

In dyeing processing, it is necessary to sufficiently express the latent shrinking force of the spun yarn or the cloth by scouring, a relaxing step, a dyeing step or the like, and it is desirable to use a jet dyeing machine. It is particularly desired to subject the fabric to a uniform and sufficient relaxing treatment at a temperature of about 70 to 80°C for about 10 to 20 minutes in the scouring and relaxing steps, and subsequently raise the temperature. It is also preferred to use a softening agent.

The woven fabric of the fourth aspect may be subjected to singeing, or mercerization or the like in order to improve the quality, texture and physical properties of the other fiber, in particular, cellulose fiber. However, one of the characteristics of the present invention resides in that the woven fabric can be finished without conducting special singeing, an alkali treatment, an acid treatment,

shearing, or the like for obtaining the anti-pilling property of any synthetic fiber. The knit fabric is also finished without conducting an alkali treatment or an acid treatment for obtaining the anti-pilling property of any synthetic fiber. The knit fabric may be subjected to resin processing for obtaining the anti-pilling property of the other fiber, skin care, antibacterial and deodorant processing, or the like.

Examples

The present invention is specifically illustrated by the following examples and comparative examples, which do not limit the present invention in any way.

Examples 1 to 5 and Comparative Examples 1 to 6

Now, the first aspect of the present invention is described by way of examples.

In the Examples and the Comparative Examples, a polyester resin having an intrinsic viscosity of 0.63 was used, and a spinneret for each of Y-shaped, hollow and solid fibers was used. A mass of the resin was spun at a polymer temperature of 290°C and a spinning rate of 1,600 m/min., and drawn at a rate of 140 m/min. at a temperature of 112°C and at draw ratios of 2.34, 2.84 and 2.60 in cases of a Y-shaped fiber, a hollow fiber (round, triangular or square-lattice(田)-shaped), and a solid fiber, respectively. In each case, a polyester staple fiber having a cut length of 38 mm and a crimp number of about 14/25 mm was produced.

For bundle spinning, a Murata Vortex Spinner MVS manufactured by Murata Machinery, Ltd. was used to perform spinning at a nozzle pressure of 0.45 MPa and a spinning-out rate of 350 m/min. However, in Example 5, the

spinning-out rate was set to 400 m/min., and in Comparative Example 6, only the spinning-out speed was set to 200 m/min.

The twist coefficient of the ring spun yarn of Comparative Example 1 was 3.2. In all the cases, an English cotton yarn count of 30 was obtained. In the case of the smooth structure of knit fabrics, the spun yarns were knit into a gauge of 22, a loop length of 325 mm, and a wale number of 100. In the case of the sheeting structures, the spun yarns were knit at a gauge of 28, a loop length of 275 mm and a wale number of 100. The cloths were unwounded, subjected to wet treatment, dried, and subjected to intermediate setting at 180°C for 40 seconds. Thereafter, the smooth structures and the sheeting structures were dyed (with 0.8% omf of a fluorescent disperse dye at 130°C for 20 minutes) in separate batches using a high-pressure jet dyeing machine, reduced, washed, dehydrated, dried, and then subjected to finish setting at 160°C for 60 seconds.

Conditions for evaluating the knit fabrics were as follows:

(1) Ultraviolet shielding rate and visible ray transmittance:

A UV-3100 PC (manufactured by Shimadzu Corp.) equipped with an integrating sphere attachment ISR-3100; Integrating sphere having an inner diameter of 60 mm (with an ultraviolet band pass filter) was used to carry out the measurements under the following conditions:

Standard white plate: barium sulfate

Wavelength for measuring ultraviolet shielding rate: 280 to 400 nm

Wavelength for measuring visible ray transmittance: 380 to 780 nm

(2) Cloth thickness:

Two pieces of cloth were piled each other so as to measure the thickness at the center portion of the piled pieces of cloth at 5 points along the lengthwise direction. Then, the measured values were averated.

(3) Anti-pilling property:

Measured according to the A method in JIS L 1076 (determined in 5 hours with an ICI type tester).

(4) Evaluation of raw materials and cloth:

Evaluation was made in accordance with the following three ranks:

A: good

B: slightly good

C: bad

The ultraviolet shielding rate and the visible ray transmittance of a cloth are generally affected by the polymer properties of the fiber, the fiber form (modified cross section degree, cross sectional shape, the presence and the amount of crimps), the kind and content of inorganic particles, the fineness of monofilaments, the fineness of the yarn, the twist structure, the density of the structure, the tissue or structure, the thickness, the hue and others.

The following Table 1 shows the resultant fibers and the results of the evaluation of cloths made thereof.

Table 1

		Raw material				
		Sectional shape	Modified cross section degree	Hollow percentage (%)	TiO_2 % (by weight)	Fineness (dtex)
Example No.	1	Y-shaped	2.4	–	0.4	1.6
	2	Square lattice-shaped	–	38 (4 holes)	0.4	2.0
	3	Square lattice-shaped	–	38 (4 holes)	0.9	2.0
	4	Y-shaped	2.4	–	0.8	1.6
	5	Y-shaped	2.4	–	0.4	1.6
Comp. Example No.	1	Y-shaped	2.4	–	0.4	1.6
	2	Round-shaped	–	– Solid	0.4	1.6
	3	Round-shaped	–	– Solid	0.4	2.0
	4	Triangle-shaped	1.4	–	0.4	1.6
	5	Round-shaped	–	– Solid	3.5	2.0
	6	Y-shaped	2.4	–	0.4	1.6

Table 1 (continued)

		Spinning		
		Method	Number of naps (per 10m)	
			Length 1 mm	Length 3 mm
Example No.	1	Bundle	159	3
	2	Bundle	170	4
	3	Bundle	188	7
	4	Bundle	171	6
	5	Bundle	277	3
Comp. Example No.	1	Ring	1655	203
	2	Bundle	177	4
	3	Bundle	153	6
	4	Bundle	161	4
	5	Bundle	143	8
	6	Bundle	25	1

Table 1 (continued)

		Knit fabric: Sheeting					Total evaluation
		Pilling	Thickness (mm)	Whiteness	UV shielding rate (%)	Visible ray transmittance (%)	
Example No.	1	4-5	0.39	A	86.0	37.1	A
	2	5	0.39	A	87.6	36.4	A
	3	5	0.40	B	91.9	31.8	A
	4	4-5	0.40	B	91.3	32.8	A
	5	4	0.38	A	85.9	37.6	A
Comp. Example No.	1	2-3	0.37	A	87.9	32.3	C
	2	4	0.32	A	79.7	43.0	C
	3	4-5	0.33	A	77.8	47.2	C
	4	4-5	0.32	A	82.9	42.0	C
	5	5	0.35	C	92.2	30.1	C
	6	5	0.36	A	82.4	40.9	C

In Examples 1 to 5, the number of naps was small, and the pilling was classes 4-5 or more in the sheeting structures and also in the smooth structures, and was at a satisfactory level. The cloth thickness (bulkiness) thereof was larger than that in Comparative Examples. The ultraviolet shielding rate was high and also the visible ray transmittance was small.

In Examples 3 and 4, a slightly large amount of titanium oxide was contained, but such an amount did not interfere with the whiteness and the color-developability so that higher whiteness was obtained than in Comparative Example 5.

The fabric of Comparative Example 1 was good in both of the ultraviolet shielding rate and the visible ray transmittance, but had many naps. In particular, the pilling of the smooth structure was as poor as classes 1 to 2. The fabrics of Comparative Examples 2 to 5 did not have many naps and a pilling of class 3 or more, but were each poor in ultraviolet shielding rate and visible ray transmittance. It appears that this may be because

friction of the fibers against the metal was largely generated so that the fibers were easily interlaced; the fabrics of Comparative Examples 2 to 5 were poorer in cloth thickness than those of Examples 1 to 5, which had a large apparent fiber diameter so as to become bulky easily; and further a small surface reflectivity due to the fiber form may have some influences.

While the Y-shaped fibers of Examples 1, 4 and 5 had a cushioning property and exhibited a soft texture, the fibers of Comparative Examples 2 to 5 having a round cross section or a low modified cross section degree were poor in cloth thickness and had a hard texture, which resulted in a considerably coarse and hard feeling. The fabric of Example 5 had a larger nap number than that of Example 1, but had a soft texture close to that of ring yarn, and kept a pilling of class 4 even in the smooth fabric. Thus, the fiber of Example 5 was at a level satisfying sufficient performances.

In Comparative Example 6, which was at a level such that the yarn speed at the time of spinning was made low, the number of naps having a length of at least 1 mm decreased greatly to 25 as compared with the numbers at other levels. Thus, the anti-pilling property was improved. However, the texture thereof was a hard texture which gave a crisp feeling, since the interlacement degree was high. the fabric of Comparative Example 6 had an entirely different texture from a bulky and soft texture as observed in Examples 1 and 4, and was a knit fabric achieving a low ultraviolet shielding rate and a large visible ray transmittance.

It was seen that the fabrics of Examples 1 to 5 had a practically acceptable anti-pilling property and color

developability and had an ultraviolet shielding rate and an anti-transparency effect close to those of full-dull fibers. Bundle spinning achieves a smaller number of naps and is better in anti-pilling property than ring spinning but has a drawback of a hard texture, which is different from that of ring yarn. An improvement thereon has been difficult. Only the woven or knit fabrics satisfying the constituting requirements of the present invention can have a soft texture and an anti-pilling property, ultraviolet shielding effect, anti-transparency, color-developability and others together.

Table 2 shows the results of the evaluation of anti-pilling properties when the spun yarns described in Examples and Comparative Examples in Table 1 were used to produce smooth structures.

Table 2

	Example No.				
	1	2	3	4	5
Cloth thickness (mm)	0.63	0.68	0.70	0.64	0.63
Pilling (class)	4-5	5	4-5	4-5	4

Table 2 (continued)

	Comparative Example No.					
	1	2	3	4	5	6
Cloth thickness (mm)	0.59	0.57	0.59	0.58	0.62	0.63
Pilling (class)	1-2	3	4	4	4-5	5

Examples 6 to 12 and Comparative Examples 7 to 11

These examples describe the second aspect of the present invention.

In both of the Examples and the Comparative Examples, a homopolymer polyester resin (polyethylene terephthalate) was used. The resin was spun at a conventional melting

temperature, and then subjected to drawing/crimping step conditions including a drawing temperature of 190°C and a crimpling temperature of 110°C, to obtain raw material fibers having a sharply Y-shaped cross sectional shape with 1.6T and 38 mm (modified cross section degree: 2.4).

For air-jet interlacing (bundle) spinning, a Murata Vortex Spinner MVS manufactured by Murata Machinery, Ltd. was used to perform spinning at a nozzle pressure of 0.45 MPa and a spinning-out speed of 350 m/min. in each case except that the spinning-out speed was 400 m/min. in Example 6 and the spinning-out speed was 200 m/min. in Comparative Example 4. The twist coefficient of the ring spun yarn was 3.2. Both of the spun yarns had an English cotton yarn count of 30.

Graft polymerization process was performed under the following conditions for the raw material fibers and the spun yarns. Each of them was scoured with 1 g/L of a Noigen HC in an Overmayer machine, and then washed with hot water. The resultant was subjected to graft polymerization processing with 20% omf of 100% methacrylic acid, 1.0% omf of a dispersing agent, 1.0% omf of a swelling agent, 0.8% omf of soda ash at a bath ratio of 1/10 and 100°C for 40 minutes. The graft degree was 16%. Thereafter, the resultant was washed with hot water, and neutralized with 4.0% omf of soda ash and 0.15% omf of sodium tripolyphosphate at 70°C. Next, the resultant was subjected to treatment for conversion into a sodium salt at 70°C while charging 12% omf of soda ash and 0.15% omf of sodium tripolyphosphate in three portions. The resultant was washed with hot water. The raw material fibers and the spun yarns had a nominal water content of 7.2%. Only the

using amounts of the above-mentioned chemicals were changed to yield graft-polymerization-processed raw material fibers having a graft polymerization degrees of 26% and 11%, respectively. The water contents therein were 12.1% and 4.4%, respectively after the sodium-salt-conversion treatment. These graft-polymerization-processed raw material fibers in the form of a knit fabric were used to carry out the sodium-salt-conversion and subsequent treatments. The mixed-spinning ratio of the graft-polymerization-processed raw material fibers used in each of the bundle spun yarns, knit fabric properties, and the results of the evaluations are shown in Table 3. Herein "omf" means "% by weight relative to fiber weight".

The spun yarns were each knit into a smooth structure (a gauge of 22, a loop length of 325 mm, and 100W), and further the cloths were each unwounded, subjected to wet treatment, dried, and subjected to intermediate setting at 180°C for 40 seconds. Next, chemicals were used in amounts corresponding to the graft degree to carry out the sodium-salt-conversion treatment, and then the resultant was washed with hot water. Thereafter, the resultant was dehydrated and dried and then subjected to finish setting at 160°C for 60 seconds, so as to yield a gray smooth knit fabric.

The properties of the spun yarns and the cloths were measured and evaluated under the following conditions:

(5) The number of yarn naps:

The number of naps having a nap length of 1 mm or more and less than 3 mm per 10 meters, and that of naps having a nap length of at least 3 mm per 10 meters are shown. As a measuring device, an F-1 index tester manufactured by Shikibo Ltd. was used.

(6) Nominal water content:

According to JIS L 1095.

(7) Color fastness to light:

According to JIS L 0842, Ultraviolet Ray Carbon Arc Lamp Light Test (the third light exposure method).

(8) Dimensional change:

According to the F-1 method in JIS L 1018 (screen drying).

(9) Anti-pilling property:

According to the A method in JIS L 1076 (ICI model, 5 hours).

(10) Texture:

According to tactile impression of five panels.

A: soft with good dry feeling

B: somewhat slimy feeling

C: considerably slimy feeling, and considerably coarse and hard feeling

(11) In the column of total evaluation, A, B and C mean "good", "somewhat good" and "bad", respectively.

Table 3

Example No.	Nominal water content in raw material fiber (%)	Mixing ratio (%)	
		Grafted raw material fiber	Unprocessed raw material fiber
Comp. Ex. 7	12.1	100	0
Example 6	12.1	50 Core	50 Sheath
Example 7	12.1	30 Sheath	70 Sheath
Comp. Ex. 8	7.2	100	0
Example 8	7.2	40	60
Example9	4.4	50	50
Comp. Ex. 9	4.4	100	0
Example 10	12.1	60 Core	40 Sheath
Example 11	12.1	30 Core	70 Sheath
Comp. Ex. 10	12.1	100	0

Table 3 (continued)

	Cotton mixing method/ Spinning method	Nominal water content in spun yarn (%)
Comp. Ex. 7	Card mixing/ Bundle spinning	12.1
Example 6	Sliver mixing/ Bundle spinning	6.5
Example 7	Sliver mixing/ Bundle spinning	3.6
Comp. Ex. 8	Card mixing/ Bundle spinning	7.3
Example 8	Card mixing/ Bundle spinning	3.0
Example9	Card mixing/ Bundle spinning	2.2
Comp. Ex. 9	Card mixing/ Bundle spinning	4.4
Example 10	Air-jet interlacing bundle-spun yarn obtained by sliver mixing with filaments	5.3
Example 11	Sliver mixing/ Bundle spinning	3.6
Comp. Ex. 10	Card mixing/ Bundle spinning	12.1

Table 3 (continued)

	Number of yarn naps		Dimensional change	
	1 mm or more and less than 3 mm	3 mm or more	Course	Wale
Comp. Ex. 7	171	4	−14.3	−8.2
Example 6	168	3	−4.9	−2.9
Example 7	165	3	−2.0	−1.6
Comp. Ex. 8	166	3	−10.6	−5.7
Example 8	171	3	−2.1	−1.0
Example9	163	3	−1.9	−0.3
Comp. Ex. 9	1660	203	−3.5	−1.6
Example 10	134	2	−3.1	−0.8
Example 11	282	4	−2.1	−1.8
Comp. Ex. 10	25	1	−11.6	−6.0

Table 3 (continued)

	Texture		Pilling (class)	Color fastness to light (class)	Total evaluation
	Wet state	Dry state			
Comp. Ex. 7	A	C	4-5	≤4	C
Example 6	A	B	4	4	A
Example 7	A	A	4	≥4	A
Comp. Ex. 8	A	C	4-5	2	C
Example 8	A	A	4	4	A
Example9	A	B	4	≥4	A
Comp. Ex. 9	A	B	2	≥4	C
Example 10	A	A	4	≥4	A
Example 11	A	A	4	≥4	A
Comp. Ex. 10	C	C	5	≥4	C

The fibers of Examples 6, 7 and 11 were each a fiber subjected to sliver mixing in such a manner that the graft-polymerization-processed fiber was arranged in a larger amount in the core region and the unprocessed raw material fiber was arranged in a larger amount in the sheath region.

The yarns of Examples 6 to 11 had the better anti-pilling property than the ring spun yarn of Comparative Example 9. Probably, the small number of naps caused by the spinning method might have contributed thereto.

The fabrics of Comparative Examples 8 and 9 had a high nominal water content, but had a slimy feeling in humidity, were poor in wearing feeling, and suffered from a high dimensional change insufficient for dimensional stability, that is one of the characteristics of polyester. In contrast, in Examples 6 to 11, the unprocessed raw material fiber was mixed, or the structure, in which the graft-polymerization-processed yarn was arranged in a larger amount in the inner layer region of the spun yarn, was formed, thereby achieving a dry feeling without damaging hygroscopicity nor producing a slimy feeling in humidity.

This made it possible to give a high comfortableness when they were worn and to yield a practically acceptable color fastness to light.

The fiber of Example 10 was made to have a structure in which the surface of spun yarn was covered with multi-filaments, thereby obtaining the same advantageous effects. In Example 10, the sliver mixed fiber of Example 6 was used to spin out a bundle spun yarn of a yarn count of 40. A nozzle (P133 model) manufactured by Heberleine Fiber Technology Inc. was used to interlace the spun yarn with a 55T, 36 filament false-twisted yarn having a Y-shaped cross section (modified cross section degree: 2.0, titanium oxide content: 0.4% by weight) at a filament feed rate of + 0.4%, a spun yarn feed ratio of - 0.2%, an air pressure of 4.0 kg/cm^2 and a speed of 200 m/min., to yield an interlaced yarn. The yarn was an interlaced spun yarn having an interlacement degree of 82 per meter and corresponding to a yarn count of 29. The interlaced spun yarn was a yarn in a form relatively covered with the filaments, and exhibited a well-proportioned external appearance having a small gloss difference between the filaments and the spun yarn and a small number of naps. The interlaced spun yarn had a graft-polymerization-processed fiber mixing ratio of 43.6%, and had a structure in which a large percentage of this fiber was arranged in the inner layer region of the spun yarn. The interlaced spun yarn was subjected to dyeing, sodium-salt-conversion treatment, and finishing in the same manner as in Examples 6 to 9, so as to be finished into a comfortable cloth giving a dry texture even in humidity.

With the cloth of Comparative Example 10, the number of naps having a nap length of at least 1 mm fell drastically decreased to 25 as compared with in the

Examples, but the cloth had a hard texture giving a crisp feeling, and was slimy in humidity, hard and undesirable. The cloth of Example 11 had a larger nap number than the other bundle spun yarn levels, but the nap number was far smaller than that of the ring spun yarn of Comparative Example 9. The knit fabric thereof was soft, and had a cushioning property and also a good anti-pilling property of class 4.

In Comparative Example 11, a knit fabric was produced under the same conditions as those in Example 8 except that the fiber cross sectional shape was round. The texture thereof was a slimy and flat touch peculiar to the round cross section even in a dry state, and was different from the non-slimy and dry touch, or the soft texture with cushion effect as found in Example 8.

In Example 12, a bundle spun yarn having a yarn count of 55 was softly wounded (winding density: 0.26 cm^3/g) on a dyeing tube, and was graft-polymerization-processed in an Overmayer machine, to produce a graft-polymerization-processed spun yarn, which had a moisture absorption coefficient of 4.0% after sodium-salt-conversion treatment. The spun yarn had a mass corresponding to a yarn count of 49 after the graft polymerization processing. The spun yarn was subjected to mixed-spinning with filaments under the same conditions as those in Example 10 except that a 84T, 48 filament false-twisted yarn with a round cross section was used. The spun yarn had a yarn count of 29, an interlacement degree of 78 per meter, and a graft-polymerization-processed fiber mixing ratio of 59%, and exhibited a yarn form in which the surface was relatively covered with the filaments.

The spun yarn was knit, dyed, subjected to sodium-

salt-conversion treatment, and finished in the same way as in Examples 6 to 10. The nominal water content ratio of the cloth was 2.4%. The dimensional changes thereof about the course and wale were −2.9% and −1.6%, respectively, after washing. The texture was not slimy in drying and humidity, and good. The anti-pilling property was class 5, and the color fastness to light was class 4. Thus, the fabric had sufficient practical performances.

Examples 13 to 17 and Comparative Examples 12 to 17

These examples describe the third aspect of the present invention.

Measuring methods:

(12) Hot water shrinkage rate of raw material fibers:

This rate was measured according to the hot water shrinkage rate in JIS L 1015. The time for boiling water treatment was 20 minutes, and that with high boiling point type latently-crimped fibers was 20 minutes at 130°C.

(13) The number of naps of spun yarn:

The number of naps having a length of at least 1 mm per 10 meters was obtained with a F-1 index tester manufactured by Shikibo Ltd.

(14) Method for washing cloth:

A cloth was washed according to the JIS L 0217, 103 method.

(15) Flexibility of cloth:

The flexibility of a cloth was measured by the following measuring methods for a woven fabric and a knit fabric, respectively.

Woven fabric: JIS L 1096 Elongation percentage B method (constant load method: 1.47 N, one minute)

Knit fabric: JIS L 1018 Elongation percentage under a

constant load (cut strip method)

(16) Anti-pilling property of cloth:

The anti-pilling property of a cloth was measured according to the A method in JIS L 1076 (ICI type tester, 5 hours).

(17) Texture evaluation of cloth:

Softness and bulkiness were evaluated according to touch-sense judgment by five panels.

A: soft and excellent in bulkiness

B: substantially good in softness and bulkiness

C : hard, non-full, and bad.

(18) Total evaluation:

A, B and C mean "very good", "generally good", and "bad", respectively.

Example 13

Production of a latently-crimped polyester fiber I

As a polyester (A) and a polyester (B), the following were used, respectively: polyethylene terephthalate (intrinsic viscosity: 0.607, melting point: 265°C); and a copolymer polyester (intrinsic viscosity 0.637, melting point: 248°C) having, as the basic backbone thereof, polyethylene terephthalate, in which isophthalic acid constituted 4% by mole of acid components and 5-sodiumsulfoisophthalic acid constituted 2% by mole thereof. A composite spinning nozzle was used to spin the polyesters into a yarn at a polymer temperature of 282°C and a spinning rate of 1,600 m/min. Thereafter, the yarn was drawn at a draw temperature of 155°C, a draw ratio of 2.64, and a drawing rate of 140 m/min. in a drawing step, crimped, and cut. The resultant side by side latently-crimped polyester fiber I having a solid round cross section

(fineness: 2.0 dtex, cut length: 38 mm) had a hot water shrinkage rate of 37.8% (free shrinkage at 130°C for 20 minutes).

A Murata Vortex Spinner MVS manufactured by Murata Machinery, Ltd. was used to spin them latently-crimped polyester fiber into an air-jet interlacing spun yarn having an English yarn count of 30 at a nozzle pressure of 0.45 Mpa and a spinning-out speed of 400 m/min. under conditions that the sliver grain and the draft thereof were made into 300 and 180 times, respectively. The number (Y) of naps of the spun yarn was 225, the number (X) of filaments in a cross section was 98. Thus, Y/X was 2.3.

The resultant spun yarn and a cotton yarn having an English cotton yarn count of 30 were used as a weft and a warp, respectively, to produce a 2/1 twill woven fabric. This woven fabric was subjected to desizing, scoured, relaxed with a jet dyeing machine at 120°C for 20 minutes, dehydrated, dried, and then subjected to intermediate setting at 170°C for 30 seconds. Thereafter, the woven fabric was dyed with 0.8% omf of a fluorescent dispersion dye at 130°C for 30 minutes by use of a high-pressure jet dyeing machine, reduction-washed, dehydrated, dried, and subjected to singeing of cotton, followed by finish setting at 170°C for 30 seconds. The cloth quality, the flexibility and the texture were evaluated after the intermediate setting and finish setting. The results of evaluations of the resultant cloth are shown in Table 4. The woven fabric had a nap number of 160, and hardly formed nap pills after the intermediate setting and finish setting, and was a soft woven fabric having a cloth elongation percentage of 34.2% and having a slightly dry feeling.

Comparative Example 12

The latently-crimped polyester fiber obtained in Example 13 was used to produce a ring spun yarn (English yarn count: 30, and twist coefficient: 3.2) at a coarse span grain of 140, a draft of 36 times, and a spinning machine rotation speed of 9000 rpm. A woven fabric was obtained in the same way as in Example 13 except that the resultant ring spun yarn was used as a weft. The cloth quality, the flexibility and the texture were evaluated after the intermediate setting and finish setting. The results of evaluations are shown in Table 4. The elongation percentage of the cloth was 37.6%, but nap pills were formed on its entire surface in the intermediate setting step, and thus the cloth had a poor quality. The woven fabric was at such a level that the nap pills should be removed by singeing and an alkali treatment like a prior art fabric.

Comparative Example 13

Production of a latently-crimped polyester fiber II

As a polyester (A) and a polyester (B), the following were used, respectively: polyethylene terephthalate (intrinsic viscosity: 0.607, melting point: 265°C); and a copolymer polyester which had a melting point of 244.5°C and was obtained using a copolymer polyester (intrinsic viscosity: 0.646) having, as the basic backbone thereof, polyethylene terephthalate, in which diethylene glycol constituted 2.5% by mole of glycol components and isophthalic acid constituted 10% by mole of acid components, and a copolymer polyester (intrinsic viscosity: 0.390) having, as the basic backbone thereof, polyethylene

terephthalate, in which diethylene glycol constituted 3.3% by mole of glycol components and 5-sodiumsulfoisophthalic acid constituted 4.4% by mole of acid components at a weght ratio of 50:50. A composite spinning nozzle was used to spin the polyesters into a yarn at a polymer temperature of 285°C and a spinning rate of 1,600 m/min. Thereafter, the yarn was drawn at a draw temperature of 155°C, a draw ratio of 2.64, and a drawing rate of 140 m/min. in a drawing step, crimped, and cut, so as to yield a side by side latently-crimped polyester fiber (fineness: 1.0 dtex, cut length: 38 mm). The hot water shrinkage rate of this fiber was 36.5% (free shrinkage at 130°C for 20 minutes). The resultant latently-crimped polyester fiber was used to produce an air-jet interlacing spun yarn having an English cotton yarn count of 30. With this spun yarn, the number (Y) of naps was 599, the number (X) of filaments in a cross section was 197. Thus, Y/X was 3.0. The spun yarn was used for the production of products up to a finish set woven fabric, when was evaluated in the same manners as in Example 13. The results of the evaluations are shown in Table 4.

Table 4

Example No.	Spun yarn (weft)					
	Latently-crimped fiber Fineness (dtex)	English cotton yarn count	Spin-ning method	No. of filaments in cross section X	No of naps Y	Y/X
Example 13	2.0	30	Bundle	98	225	2.3
Comp. Ex. 12	2.0	30	Ring	98	1901	19.4
Comp. Ex. 13	1.0	30	Bundle	197	599	3.0

Table 4 (continued)

	Cloth properties				Total evaluation
	Nap quality	Pilling (class)	Texture	Stretch: Elongation (%)	
Example 13	A	4	B Soft	34.2	B
Comp. Ex. 12	C	1	A Soft	37.6	C
Comp. Ex. 13	B	1-2	B Soft	36.1	C

The yarn of Comparative Example 12 was a conventional ring spun yarn, and the elongation percentage of the woven fabric was 37.6% but nap pills were already formed on its entire surface in the intermediate setting stage. Thus, the cloth of Comparative Example 12 had a poor quality, and was at such a level that the nap pills should be removed by singeing and an alkali treatment like a prior art fabric. The yarn of Comparative Example 13 had a large number of naps, and nap pills were already formed in the intermediate setting step like the yarn of Comparative Example 12 but were fewer than those in Comparative Example 12. The quality after the finish setting was also at such a level that the nap pills should be removed by singeing, an alkali treatment or shearing, and was poorer than the quality of Example 13.

Example 14

Production of a Y-shaped cross section fiber

Using a spinning nozzle for a Y-shaped cross section fiber, polyethylene terephthalate (intrinsic viscosity: 0.633) was sput at a polymer temperature of 288°C and a spinning rate of 1,600 m/min. Thereafter, the spun yarn was drawn at a draw temperature of 112°C, a draw ratio of

2.32, and a drawing rate of 140 m/min. in a drawing step, crimped, and cut. The resultant Y-shaped cross section low-shrinkage fiber (fineness: 1.3 dtex, modified cross section degree: 2.4, cut length: 38 mm) had a boiling water shrinkage rate of 1.4%.

The resultant low-shrinkage fiber with a Y-shaped cross section and the latently-crimped polyester fiber II were used and subjected to card cotton mixing, and then a Murata Vortex Spinner MVS manufactured by Murata Machinery, Ltd. was used to spin them at a nozzle pressure of 0.45 MPa and a spinning-out speed of 400 m/min. under conditions that the sliver grain and the draft thereof were set to 200 and 160 times, respectively, so as to produce a bundle spun yarn having an English cotton yarn count of 40. The mixing ratio of the latently-crimped polyester fiber II in the spun yarn was 20%, while the mixing ratio of the low-shrinkage fiber was 80%. With this the spun yarn, the number (Y) of naps was 245, the number (X) of filaments in a cross section was 120. Thus, Y/X was 2.20.

The resultant spun yarn was used to produce a knit fabric with a sheeting structure having a gauge of 28 and a loop length of 325 mm per 100 wales. The knit fabric was unwounded, and the fabric together with a scouring agent was subjected to a relaxing heat-shrinkage treatment at 80°C for 10 minutes in a jet dyeing machine. Thereafter, the fabric was heated to 110°C, subjected to heat shrinkage treatment for 10 minutes, and then dehydrated and dried. The fabric was subjected, in the existing width, to intermediate setting at 170°C for 40 seconds. Thereafter, a high-pressure jet dyeing machine was used to dye the fabric with 0.8% omf of a fluorescent dispersion dye at 130°C for 20 minutes, and then the fabric was reduced,

washed, dehydrated, dried, and subjected, in the existing width, to finish setting at 160°C for 60 seconds. The results of evaluations of the resultant cloth are shown in Table 5.

Comparative Example 14

A ring spun yarn having the same fiber structure as Example 14 was produced except that the spun yarn was changed to a ring spun yarn (the same production process as in Comparative Example 13), and products from a knit fabric to a finish set cloth were produced and evaluated in the same manners as in Example 14. The results of evaluations are shown in Table 5.

Example 15

Products from a spun yarn to a finish set cloth were produced and evaluated in the same manners as in Example 14 except that the mixing ratio of the latently-crimped polyester fiber II in Example 14 was changed to 30% and the Y-shaped cross section fiber was changed to a rayon fiber (fineness: 1.7 dtex, cut length: 38 mm). The results of evaluations are shown in Table 5.

Example 16

Production of a latently-crimped polyester fiber III

As a polyester (A) and a polyester (B), the following were used, respectively: polyethylene terephthalate (intrinsic viscosity: 0.627, melting point: 265°C); and a copolymer polyester (intrinsic viscosity 0.607, melting point: 162°C) which had, as the basic backbone thereof, polyethylene terephthalate, and was copolymerized with 30% by mole of neopentyl glycol as a glycol component. A

composite spinning nozzle was used to spin the polyesters into a yarn at a polymer temperature of 282°C and a spinning rate of 1,700 m/min. Thereafter, the yarn was drawn at room temperature, a draw ratio of 2.55, and a drawing rate of 150 m/min. in a drawing step, crimped, and cut. The resultant side by side latently-crimped polyester fiber III having a solid round cross section (fineness: 1.6 dtex, cut length: 38 mm) had a boiling water shrinkage rate of 53.2%.

The resultant latently-crimped polyester fiber III and the above-mentioned Y-shaped cross section fiber were used to produce a bundle spun yarn, a knit fabric and an unwounded cloth in the same way as in Example 14 except that the cotton mixing method was changed to a sliver mixing method (to give a core-sheath structure in which the latently-crimped polyester fiber was arranged in a larger amount in the core and the Y-shaped cross section fiber III was arranged in a larger amount in the sheath region) and further the mixing ratio of the Y-shaped cross section fiber was changed from 80% to 70%. Next, the cloth was relaxed at 70°C. Thereafter, a finish set cloth was produced and evaluated in the same manners as in Example 14 except that the dyeing temperature, the intermediate setting temperature and the finish setting temperature were set to 100°C, 130°C, and 120°C, respectively. The results of evaluations are shown in Table 5.

Example 17

Products from a bundle spun yarn to a finish set cloth were obtained and evaluated in the same manners as in Example 16 except that the latently-crimped polyester fiber III was changed to the latently-crimped polyester fiber II

and the Y-shaped cross section fiber was changed to a conventional polyethylene terephthalate fiber with a solid round cross section (fineness: 2.0 dtex). The results of evaluations are shown in Table 5.

Comparative Example 15

Products up to a finish set cloth were obtained and evaluated in the same manners as in Example 17 except that the bundle spun yarn was changed to a bundle spun yarn having a very small number of naps, in which the number (Y) of the naps was 15, the number (X) of filaments in a cross section was 74 and Y/X was 0.2. The results of evaluations are shown in Table 5.

Comparative Example 16

Products from a spun yarn to a finish set cloth were obtained and evaluated in the same manners as in Example 14 except that a low-shrinkage fiber, which was a conventional polyethylene terephthalate fiber with a solid round cross section (fineness: 2.0 dtex) was used alone. The results of evaluations are shown in Table 5.

Comparative Example 17

Products from a spun yarn to a finish set cloth were obtained and evaluated in the same manners as in Example 14 except that the fineness of the latently-crimped polyester fiber II was changed to 4.4 dtex in Example 14. The results of evaluations are shown in Table 5.

Table 5

	Latently-crimped fiber		Low-shrinkage fiber (blend-spun fiber)				
	Fineness (dtex)	Mixing ratio (%)	Fineness (dtex)	Cross section	Modified cross section ratio	Mixing ratio (%)	Blend spinning method
Example 14	1.0	20	1.3	Y-shaped	2.4	80	Card
Comp. Ex. 14	1.0	20	1.3	Y-shaped	2.4	80	Card
Example 15	1.0	30	Rayon,1.7 dtex			70	Card
Example 16	1.6	30	1.3	Y-shaped	2.4	70	Sliver*
Example 17	2.0	30	2.0	Round	–	70	Sliver*
Comp. Ex. 15	2.0	30	2.0	Round	–	70	Sliver*
Comp. Ex. 16	–	–	2.0	Round	–	100	Card
Comp. Ex. 17	3.0	20	1.3	Y-shaped	2.4	80	Card

Table 5 (continued)

	Spun yarn properties				
	Cotton mixing method	English cotton yarn count	No. of filaments in cross section X	No. of naps Y	Y/X
Example 14	Bundle	40	120	245	2.0
Comp. Ex. 14	Ring	40	120	1380	11.5
Example 15	Bundle	40	105	203	1.9
Example 16	Bundle	40	107	235	2.2
Example 17	Bundle	40	74	155	2.1
Comp. Ex. 15	Bundle	40	74	15	0.2
Comp. Ex. 16	Bundle	40	74	170	2.3
Comp. Ex. 17	Bundle	40	101	215	2.1

Table 5 (continued)

	Cloth properties			Total evaluation
	Pilling (class)	Texture	Weight per unit area (g/m^2)	
Example 14	4	B Soft	149	B
Comp. Ex. 14	1	B Soft	152	C
Example 15	4-5	B Soft	140	B
Example 16	4	A Soft	146	B
Example 17	4	B Soft	161	o
Comp. Ex. 15	5	C Hard	139	C
Comp. Ex. 16	5	C Hard	124	C
Comp. Ex. 17	1-2	o Soft	148	C

Note: *Core-sheath form (latently-crimped fiber/low-shrinkage fiber)

The cloth of Example 14 had a small number of naps, a soft and fine-grained texture, and sufficient flexibility (elongation percentage of 30% or more under a constant load), and was finished to be bulkier and larger in weight per unit area by 20.2% than that of Comparative Example 17, which comprised no latently-crimped fiber. Its pilling was as good as class 4. The cloth of Comparative Example 14, which had the same fiber structure as that of Example 2 and was produced by conventional ring spinning, was bulky and had a soft texture, but had nap pills formed on the entire surface thereof, was poor in quality, and was as poor in pilling as class 1.

The cloth of Example 15 had a good anti-pilling property of class 4 or 5, had a moderate full feeling, was finished into a soft texture close to that of a ring spun yarn, and was finished into a level sufficient in flexibility and recoverability and suitable for inner wears. The cloth of Examples 16 and 17, which comprised the slivers having a core-sheath structure in which the latently-crimped fiber was arranged in a larger amount in the core region, had few nap pills on the knit fabric, was rich in full feeling and soft, and was as good in anti-pilling property as class 4. In particular, the yarn of Example 16, which had a strong shrinking force, was finished into a good knit fabric which was fuller and softer than that of Example 17 and was rich in flexibility and restorability.

The cloth of Comparative Example 15, which had the same structure as that of Example 17, was at such a level that the number of yarn naps was small, had an excessively large interlacement degree, and did not utilize the features of the latently-crimped fiber. The yarn of

Comparative Example 16 was also finished into a hard texture which was not very different from an air-jet interlacing spun yarn resulting from conventional monofilaments, and hardly had flexibility. The cloth of Comparative Example 16 was good in pilling, but had a small cloth thickness and a hard texture, and was inferior to those of Examples. The cloth of Comparative Example 17 had a small number of naps, but nap pills were frequently generated in the step of exhibiting crimps of the knit fabric, although the number of nap pills was smaller than that in Comparative Example 14,. Thus, Comparative Example 14 was poor in quality, and unpractical. This may be because the cloth of Comparative Example 14 had a structure in which the latently-crimped fiber was arranged in a larger amount in the surface of the spun yarn than those of Examples.

Examples 18 to 22 and Comparative Examples 18 to 21

These examples describe the present invention by way of examples.

(19) Boiling water shrinkage rate of raw material fiber:

The boiling water shrinkage rate of a raw material fiber was measured according to the hot water shrinkage rate in JIS L 1015. The time for treatment with boiling water was 20 minutes.

(20) Thermal stress of raw material fiber:

A thermal stress-strain measuring device EMA/SS 100 manufactured by Seiko Instruments Inc. was used to measure the thermal stress under an initial load of 0.059 cN/dtex and a heating rate of 10°C/min.

(21) The number of naps of spun yarn:

The number of naps having a length of at least 1 mm per 10 meters was obtained by use of a F-1 index tester manufactured by Shikibo Ltd.

(22) Anti-pilling property of cloth:

The anti-pilling property of a cloth was measured according to the A method in JIS L 1076 (ICI type tester, 5 hours).

(23) Texture evaluation of cloth:

Softness and bulkiness were evaluated according to touch-sense judgment of by five panels.

A: soft, and excellent in bulkiness

B: substantially good in softness and bulkiness

C: hard, non-full, and bad.

(24) Total evaluation:

A, B and C mean "very good", "generally good" and "bad", respectively.

Example 18

Using a spinning nozzle for a conventional fiber, a copolymer polyester (intrinsic viscosity: 0.623) having, as its basic backbone, polyethylene terephthalate in which isophthalic acid constituted 10% by mole of acid components was spun into a yarn (containing 0.35% by weight of titanium oxide) at a polymer temperature of 282°C and a spinning rate of 1100 m/min. Thereafter, the yarn was drawn at room temperature, a draw ratio of 3.75, and a drawing rate of 140 m/min. in a drawing step, crimped, and cut. The resultant high-shrinkage fiber having a solid round cross section (fineness: 1.6 dtex, cut length: 38 mm) had a boiling water shrinkage rate of 24.8% and a maximum thermal stress of 0.09 cN/dtex (at 148°C).

Separately, using a spinning nozzle for a conventional

fiber, polyethylene terephthalate (intrinsic viscosity: 0.633) was spun into a yarn (containing 0.35% by weight of titanium oxide) at a polymer temperature of 288°C and a spinning rate of 1,600 m/min. Thereafter, the yarn was drawn at a draw temperature of 112°C, a draw ratio of 2.34, and a drawing rate of 140 m/min. in a drawing step, crimped, and cut. The resultant low-shrinkage fiber with a solid round cross section (fineness: 1.6 dtex, cut length: 38 mm) had a boiling water shrinkage rate of 1.2%.

The resultant high-shrinkage fiber with the solid round cross section and the low-shrinkage fiber with the solid round cross section were subjected to card cotton mixing, and then a Murata Vortex Spinner MVS manufactured by Murata Machinery, Ltd. was used to spin them at a nozzle pressure of 0.45 MPa and a spinning-out speed of 400 m/min. under conditions that the sliver grain and the draft thereof were set to 300 and 180 times, respectively, to produce a bundle spun yarn having an English cotton yarn count of 30. The mixing ratio of the high-shrinkage fiber in the spun yarn was 20%, while the mixing ratio of the low-shrinkage fiber was 80%. About the spun yarn, the number (K) of naps was 292, the number (A) of filaments in a cross section was 123. Thus, K/A was 2.37.

The resultant spun yarn was used to produce a knit fabric with a sheeting structure having a gauge of 28 and a loop length of 325 mm per 100 wales. The knit fabric was unwounded, and the fabric together with a scouring agent was subjected to a relaxing heat-shrinkage treatment at 80°C for 10 minutes in a jet dyeing machine. Thereafter, the fabric was heated to 110°C, and subjected to heat shrinkage treatment for 10 minutes. The fabric was then dehydrated, dried, and subjected, in the existing width, to

intermediate setting at 170°C for 40 seconds. Thereafter, a high-pressure jet dyeing machine was used to dye the fabric with 0.8% omf of a fluorescent dispersion dye at 130°C for 20 minutes, and then the fabric was reducced, washed, dehydrated, dried, and subjected, in the existing width, to finish setting at 160°C for 60 seconds.

The results of evaluations of the resultant cloth are shown in Table 6. The anti-pilling property of the cloth was class 4 or 5, and the texture thereof was judged to be generally good.

Example 19

A spinning nozzle for a hollow cross section fiber was used to spin the same copolymer polyester (intrinsic viscosity: 0.625) as in Example 18 into a yarn (containing 0.35% by weight of titanium oxide) at a polymer temperature of 282°C and a spinning rate of 1,500 m/min. Thereafter, the yarn was drawn at room temperature, a draw ratio of 2.68, and a drawing rate of 140 m/min. in a drawing step, crimped, and cut. The resultant high-shrinkage fiber with a hollow cross section (fineness: 2.2 dtex, hollow percentage: 20%, cut length: 38 mm) had a boiling water shrinkage rate of 39.1% and a maximum thermal stress of 0.18 cN/dtex (at 105°C).

A cloth was obtained and evaluated in the same manners as in Example 18 except that the high-shrinkage fiber in Example 18 was changed to the resultant high-shrinkage fiber with a hollow round cross section, and the low-shrinkage fiber was changed to a rayon fiber (fineness: 1.7 dtex, cut length: 38 mm). The results of evaluations are shown in Table 6.

Example 20

A cloth was obtained and evaluated in the same manners as in Example 18 except that the high-shrinkage fiber in Example 18 was changed to the same high-shrinkage fiber with a hollow round cross section as in Example 19, and further the low-shrinkage fiber with a hollow round cross section having the fineness of 1.6 dtex was changed to a low-shrinkage fiber with a solid round cross section having a fineness 0.8 dtex (boiling water shrinkage rate: 1.2%). The results of evaluations are shown in Table 6.

Example 21

A cloth was obtained and evaluated in the same manners as in Example 20 except that the card mixing method was changed to a sliver mixing method (to produce a core-sheath structure in which the high-shrinkage fiber was arranged in a larger amount in the core region and the low-shrinkage fiber was arranged in a larger amount in the sheath region) and further the mixing ratio of the low-shrinkage fiber with a solid round cross section was changed from 80% to 70%. The results of evaluations are shown in Table 6.

Example 22

Using a spinning nozzle for a Y-shaped cross section fiber the same copolymer polyester (intrinsic viscosity: 0.625) as in Example 18 was spun at a polymer temperature of 282°C and a spinning rate of 1,400 m/min. into a yarn (containing 0.35% by weight of titanium oxide). Thereafter, the spun yarn was drawn at room temperature, a draw ratio of 2.32, and a drawing rate of 140 m/min. in a drawing step, crimped, and cut. The resultant high-shrinkage fiber with a Y-shaped cross section (fineness: 1.6 dtex, modified

cross section degree: 2.2, cut length: 38 mm) had a boiling water shrinkage rate of 36.4% and a maximum thermal stress of 0.17 cN/dtex (at 109°C).

Using a spinning nozzle for a Y-shaped cross section fiber, the same copolymerized polyethylene terephthalate (intrinsic viscosity: 0.633) as in Example 18 was spun at a polymer temperature of 288°C and a spinning rate of 1,600 m/min. into a yarn (containing 0.35% by weight of titanium oxide). Thereafter, the spun yarn was drawn at a draw temperature of 112°C, a draw ratio of 2.34, and a drawing rate of 140 m/min. in a drawing step, crimped, and cut. The resultant low-shrinkage fiber with a Y-shaped cross section (fineness: 1.1 dtex, modified cross section degree: 2.4, cut length: 38 mm) had a boiling water shrinkage rate of 1.3%.

The resultant high-shrinkage fiber with a Y-shaped cross section and the resultant low-shrinkage fiber with a Y-shaped cross section were subjected to card cotton mixing, and then a Murata Vortex Spinner MVS manufactured by Murata Machinery, Ltd. was used to spin them at a nozzle pressure of 0.45 MPa and a spinning-out speed of 400 m/min. under conditions that the sliver grain and the draft thereof were set to 200 and 160 times, respectively, to produce a bundle spun yarn having an English cotton yarn count of 40. The mixing ratio of the high-shrinkage fiber in the spun yarn was 20%, while the mixing ratio of the low-shrinkage fiber was 80%. With this spun yarn, the number (K) of naps was 289, the number (A) of filaments in a cross section was 126. Thus, K/A was 2.31.

The resultant spun yarn was used to produce a knit fabric in the same way as in Example 18. The fabric was subjected to steps from dyeing to finish setting.

The results of evaluations of the resultant cloth are shown in Table 6. The anti-pilling property of the cloth was class 4, and the texture was excellent in softness and bulkiness and judged to be very good.

Example 23

A cloth was obtained and evaluated in the same manners as in Example 22 except that the card mixing method was changed to a sliver mixing method (to produce a core-sheath structure in which the high-shrinkage fiber was arranged in a larger amount in the core region and the low-shrinkage fiber was arranged in a larger amount in the sheath region) and further the mixing ratio of the low-shrinkage fiber with a solid round cross section was changed from 80% to 70% in Example 22. The results of evaluations are shown in Table 6.

Comparative Example 18

A cloth was obtained and evaluated in the same manners as in Example 18 except that the high-shrinkage fiber was changed to a high-shrinkage fiber with a solid round cross section having a boiling water shrinkage rate of 12.9% and a maximum thermal stress of 0.05 cN/dtex (at 160°C). The results of evaluations are shown in Table 6.

Comparative Example 19

A cloth was obtained and evaluated in the same manners as in Example 18 except that in Example 18 the high-shrinkage fiber with a solid round cross section was changed to a high-shrinkage fiber with a hollow round cross section (fineness: 2.2 dtex, hollow percentage: 20%) and further the bundle spun yarn was changed to a ring spun

yarn (a coarse yarn of 140 in grain was ring-spun at a draft of 36 times, and a fine spinning machine rotating number of 9000 rpm). The results of evaluations are shown in Table 6.

Comparative Example 20

A cloth was obtained and evaluated in the same manners as in Comparative Example 19 except that the ring spun yarn in Comparative Example 19 was changed to a bundle spun yarn. The results of evaluations are shown in Table 6.

Comparative Example 21

A cloth was obtained and evaluated in the same manners as in Example 18 except that a solid round cross section low-shrinkage fiber having a fineness of 0.8 dtex was used alone. The results of evaluations are shown in Table 6.

Table 6

	Raw material fiber structure				
	High-shrinkage fiber				
	Fineness (dtex)	Cross sectional shape	Boiling water shrinkage rate (%)	Thermal stress (cN/dtex)	Mixing ratio (%)
Example 18	1.6	Round	24.8	0.09	20
Example 19	2.2	Hollow	39.1	0.18	20
Example 20	2.2	Hollow	39.1	0.18	20
Example 21	2.2	Hollow	39.1	0.18	30
Example 22	1.6	Y-shaped	36.4	0.17	20
Example 23	1.6	Y-shaped	36.4	0.17	30
Com. Ex. 18	1.6	Round	12.9	0.05	20
Com. Ex. 19	2.2	Hollow	39.1	0.18	20
Com. Ex. 20	2.2	Hollow	39.1	0.18	20
Com. Ex. 21	–	–	–	–	–

Table 6 (continued)

	Raw material fiber structure		
	Low-shrinkage fiber		
	Fineness (dtex)	Cross sectional shape	Mixing ratio (%)
Example 18	1.6	Round	80
Example 19	1.7	(Rayon)	80
Example 20	0.8	Round	80
Example 21	0.8	Round	70
Example 22	1.1	Y-shaped	80
Example 23	1.1	Y-shaped	70
Com. Ex. 18	1.6	Round	80
Com. Ex. 19	1.6	Round	80
Com. Ex. 20	1.6	Round	80
Com. Ex. 21	0.8	Round	100

Table 6 (continued)

	Spun yarn				
	Raw material fiber mixing method/spinning method	English cotton yarn count	No. of filaments in cross section (A)	Actually-measured No. of naps (K)	K/A
Example 18	Card/bundle	30	123	292	2.37
Example 19	Card/bundle	30	110	268	2.44
Example 20	Card/bundle	30	215	563	2.62
Example 21	Core-sheath sliver/bundle	30	199	537	2.70
Example 22	Card/bundle	40	126	289	2.31
Example 23	Core-sheath sliver/bundle	40	122	291	2.39
Com. Ex. 18	Card/bundle	30	123	289	2.35
Com. Ex. 19	Card/Ring	30	116	1288	11.1
Com. Ex. 20	Card/bundle	30	116	21	0.18
Com. Ex. 21	Card/bundle	40	184	207	1.13

Table 6 (continued)

	Cloth (sheeting)		Total evaluation
	Texture	Anti-pilling (class)	
Example 18	B: Soft and bulky	4-5	B
Example 19	A: Soft and bulky	4	A
Example 20	A: Soft and bulky	4	A
Example 21	A: Soft and bulky	4	A
Example 22	A: Soft and bulky	4	A
Example 23	A: Soft and bulky	4	A
Com. Ex. 18	C: Hard and cloth-thin	5	C
Com. Ex. 19	A: Soft and bulky	2	C
Com. Ex. 20	C: Hard and cloth	5	C
Com. Ex. 21	C: Hard and cloth	5	C

As described above, in Examples 18 to 23, the spun yarns had a small number of naps, and the anti-pilling property of the cloths was class 4 or more. Their texture was soft and excellent in bulkiness. In Example 18, the shrinkage difference between the fibers was smaller than that in other Examples but the texture thereof was not bad. In Comparative Example 18, the thermal stress of the high-shrinkage fiber was weak, and the shrinkage was insufficient. The yarn of Comparative Example 18 had a hard texture close to that of a conventional bundle spun yarn. The cloth of Comparative Example 19 had a soft and bulky texture but was poor in anti-pilling property. The texture of Examples 19 to 22 was close to that of ring spun yarn, and was a soft texture having a cushioning property, which was different from the hard and crisp texture of conventional bundle spun yarn. In particular, about Examples 5 and 6, this tendency was strong because of their Y-shaped fiber cross sectional shape. Example 23 was finished into a cloth having a highly-full and soft texture.

The cloth of Comparative Example 20 was a largely-shrunk cloth having a slightly-full and hard texture. It appears that this is based on the following reason: this spun yarn was a spun yarn having a larger number of naps and having a higher interlacement degree than those of Examples; therefore, the high-shrinkage was hindered from being shrunk so that stress relaxation occurred among the fibers so as not to exhibit bulkiness and fullness. In Comparative Example 21, the very fine fiber was used; however, the cloth texture was a flat and cloth-thin texture, and was different from the bulky and highly-soft texture observed in the Examples. Cloths having a soft texture and anti-pilling property close to those of ring

spun yarn have been able to be finished by preparing yarn mixed-spun with a high-shrinkage fiber and specifying the number of naps of the spun yarn as in the Examples.

INDUSTRIAL APPLICABILITY

According to the first aspect of the present invention, it is possible to obtain, at low costs, a polyester-staple-fiber-containing cloth which has a soft texture, which gives a low transparency and a high ultraviolet shielding rate without using any full-dull fiber even when the cloth is thin and white, which is excellent in quick drying property and color-developability, and which also has an excellent anti-pilling property even when no modified polyester fiber is used. Examples of preferable applications include clothes such as shirts, blouses, casual knit fabrics, golf wear knitting, sweaters, jackets, pants, skirts, swimsuits, underwear and uniforms; caps and hats, umbrellas, scarves, towels, gloves, curtains, pillow covers, cushion side cloths, sheets, futon (or bedding) side cloths, and diapers.

According to the second aspect, it is possible to obtain a polyester staple fiber woven or knit fabric that has a high hygroscopicity, that can produce an improvement in dimensional instability and slimy texture in humidity, which are drawbacks of conventional graft-polymerized fibers, and that simultaneously has an excellent anti-pilling property, since a single component polyester fiber, which is graft-polymerization-processed, is used without using any two-component composite spun fiber having hygroscopicity, and further the polyester fiber is made up to an air-jet interlacing spun yarn. Furthermore, the hardness of the air-jet interlacing spun yarn can be

improved by use of a polyester fiber having a specified cross sectional shape. Thus, a woven or knit fabric having a soft texture can be obtained. As a result, it is possible to obtain a soft polyester staple fiber woven or knit fabric having sufficient hygroscopicity and anti-pilling property without impairing the properties of polyester. The second aspect can be used in wide fields of woven or knit fabrics for inner and outer wears, towels, interlining cloths, interior goods such as mats and sheets, secondary materials, night clothes, and others.

According to the third aspect, it is possible to provide a staple fiber woven or knit fabric which is a staple fiber woven or knit fabric comprising bundle spun yarns made mainly of a polyester staple fiber but has both of an anti-pilling property and soft bulkiness only by a simple treatment, such as hot water treatment, and which also has excellent flexibility. According to the present invention, therefore, it is unnecessary to use a spandex bare yarn knitting machine essential for obtaining the flexibility and recoverability of a cloth such as bare sheeting, and it is possible to produce easily a knit fabric which has anti-pilling property and is bulky and rich in softness and flexibility recoverability by means of a conventional knitting machine. The woven or knit fabric is optimally used for sports underwear knitting, sports outerwear knitting, casual knitting, sweaters, jackets, pants, skirts, interlining cloths, towels, scarves, belly-warmer ties, socks, and cushion side cloths.

According to the fourth aspect, it is possible to provide a staple fiber woven or knit fabric which is made mainly of a polyester staple fiber but has both of an anti-pilling property and soft bulkiness only by a simple

treatment, such as hot water treatment, without requiring the use of any conventional modified polyester fiber for obtaining anti-pilling property nor causing production troubles substantially in spinning and dyeing processing, and which makes use of a bundle spun yarn but has an excellent bulkiness and a soft and pleasant texture. The woven or knit fabric is optimally used for sports inner wear knitting, sports outerwear knitting, casual knitting, sweaters, jackets, pants, skirts, interlining cloths, towels, scarves, belly-warmer ties, socks, and cushion side cloths.